

**THE RESOURCES
OF THE
NEW ENGLAND - NEW YORK REGION**

**PART TWO
CHAPTER IV
ST. CROIX RIVER BASIN**

**MAINE
NEW BRUNSWICK**

NEW ENGLAND - NEW YORK INTER - AGENCY COMMITTEE

FOREWORD

This book contains one chapter of Part Two of the Report of the New England-New York Inter-Agency Committee, organized by direction of the President of the United States for the purpose of making a comprehensive survey of the land, water and related resources of the New England-New York Region.

The complete report comprises three parts:

Part One - The General Report.

Part Two - The Technical Report, with detailed studies of the river basins and special subjects.

Part Three - Reference Data.

THE RESOURCES
OF THE
NEW ENGLAND-NEW YORK REGION

CONTENTS

Part Two

Chapter I	- The New England-New York Region
Chapter II	- Subregion "A"
Chapter III	- Saint John River Basin
Chapter IV	- St. Croix River Basin
Chapter V	- Penobscot River Basin
Chapter VI	- Kennebec River Basin
Chapter VII	- Androscoggin River Basin
Chapter VIII	- Presumpscot River Basin
Chapter IX	- Saco River Basin
Chapter X	- Maine Coastal Area
Chapter XI	- Special Subjects Subregion "A"
Chapter XII	- Subregion "B"
Chapter XIII	- Piscataqua River Basin
Chapter XIV	- New Hampshire Coastal Area
Chapter XV	- Merrimack River Basin
Chapter XVI	- Massachusetts Coastal Area
Chapter XVII	- Narragansett Bay Drainage Basins
Chapter XVIII	- Pawcatuck River Basin

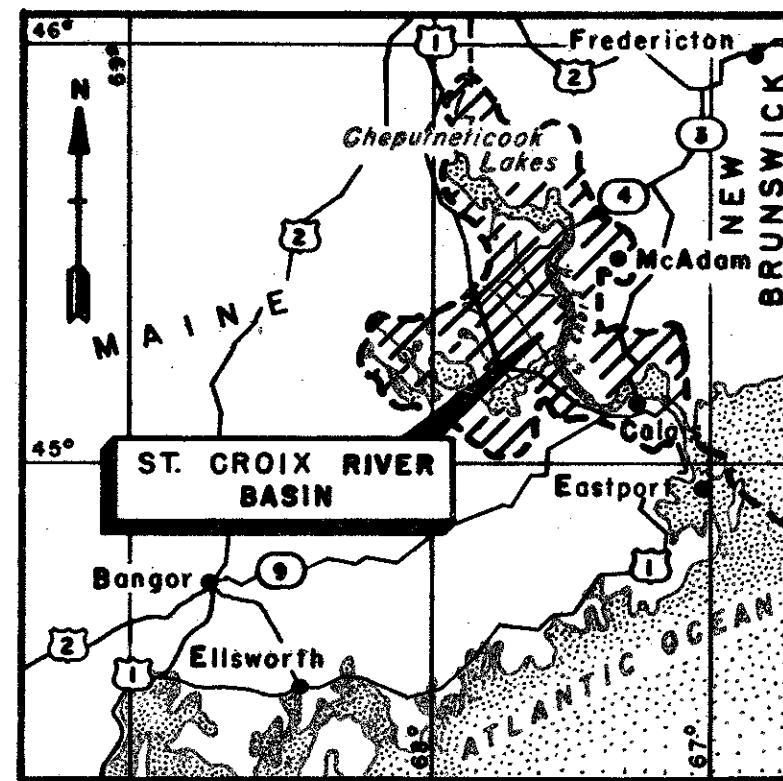
Chapter XIX	- Rhode Island Coastal Area
Chapter XX	- Thames River Basin
Chapter XXI	- Connecticut River Basin
Chapter XXII	- Housatonic River Basin
Chapter XXIII	- Connecticut Coastal Area
Chapter XXIV	- Special Subjects Subregion "B"
Chapter XXV	- Subregion "C"
Chapter XXVI	- Lake Memphremagog Drainage Basin
Chapter XXVII	- Lake Champlain Drainage Basin
Chapter XXVIII	- St. Lawrence Drainage Basin
Chapter XXIX	- Special Subjects Subregion "C"
Chapter XXX	- Subregion "D"
Chapter XXXI	- Black River Basin
Chapter XXXII	- Oswego River Basin
Chapter XXXIII	- Genesee River Basin
Chapter XXXIV	- Small Streams Tributary to Lake Ontario
Chapter XXXV	- Lake Erie - Niagara River Drainage Basin
Chapter XXXVI	- Special Subjects Subregion "D"
Chapter XXXVII	- Subregion E - Hudson River Basin
Chapter XXXVIII	- Special Subjects Subregion "E"
Chapter XXXIX	- Special Subjects, Regional

**ST. CROIX RIVER
BASIN MAP**

NEW ENGLAND - NEW YORK - INTER-AGENCY COMMITTEE

SAINT JOHN RIVER
BASIN

SAINT JOHN RIVER
BASIN



LOCATION MAP

NEW BRUNSWICK
COASTAL STREAMS

PENOBSCOT RIVER
BASIN

MAINE COASTAL
BASINS

MAINE COASTAL
BASINS

ST. CROIX RIVER
BASIN MAP

NEW ENGLAND - NEW YORK INTER-AGENCY COMMITTEE
MAY 1954

SCALE IN MILES
0 4 8

45° 30'

45° 30'

67° 30'

THE RESOURCES
OF THE
NEW ENGLAND - NEW YORK REGION

PART TWO
CHAPTER IV
ST. CROIX RIVER BASIN

MAINE
NEW BRUNSWICK

NEW ENGLAND - NEW YORK INTER-AGENCY COMMITTEE

ST. CROIX RIVER BASIN

CONTENTS

	<u>Page</u>
SECTION I - GENERAL DESCRIPTION	
Location and area, Main river, The estuary, Headwater tributaries, Other tributaries.	1
TOPOGRAPHY AND GENERAL GEOLOGY - Topography, Bedrock, Surficial geology.	4
MAPS -	7
CLIMATOLOGY AND HYDROLOGY - Temperature, Precipitation, Snowfall, Stream flow records, Run-off.	8
SECTION II - ECONOMIC DEVELOPMENT	
SETTLEMENT	1
POPULATION	1
ECONOMY	2
TRANSPORTATION	3
SECTION III - STORAGE AND STREAM FLOW REGULATION	
General, Existing storage, Operation and regulation, Potential storage.	1
SECTION IV - WATER SUPPLY	
SURFACE WATER AVAILABLE - Safe yield, Natural quality, Sanitary quality.	1
GROUND WATER AVAILABLE - Source of information, Quality.	6
WATER USE - Rural and agricultural water use, Industrial water use, Surface water use, Ground water use, Re-use.	7
DISCUSSION OF FUTURE WATER RESOURCES - Trends in water use, Future availability of water, Future quality.	12
CONTROL OF RESERVOIRS FOR PUBLIC WATER SUPPLIES -	14
CONCLUSIONS -	14

	<u>Page</u>
WATER SUPPLY PLAN - Improvement of water quality, Investigation of supplemental irrigation, Ground water investigations.	16
SECTION V - POLLUTION CONTROL	
POLLUTION CONTRIBUTED TO WATER RESOURCES - Sewage pollution, Industrial waste pollution.	1
EFFECT OF POLLUTION ON PRESENT WATER CONDITIONS - St. Croix River below Woodland, St. Croix River below Calais, Other water resources.	2
POLLUTION PREVENTION MEASURES IN EFFECT - Treatment facilities, Maine State pollution control legislation.	4
CLASSIFICATION ADOPTED FOR BEST USE OF WATER RESOURCES -	5
PROVISIONAL POLLUTION CONTROL - Costs and benefits, Purpose of provisional pollution control plans, Elements of provisional plans, Cost estimate criteria, Water condition criteria.	6
PROVISIONAL TREATMENT OR DISPOSAL FACILITIES - Treatment facilities - Provisional Plan A, Reduction of pollution, Provisional Plan A, Treatment facilities, Provisional Plan B, Reduction of pollution, Provisional Plan B, Treatment facilities - Provisional Plan C, Reduction of pollution - Provisional Plan C.	9
APPROXIMATE WATER QUALITY IMPROVEMENT - Existing water conditions, Water conditions under Provisional Plan A, Water conditions under Provisional Plan B, Water conditions under Provisional Plan C, Water condition improvement, Provisional Plan A, Water condition improvement, Provisional Plans B and C.	13
ESTIMATED COSTS FOR TREATMENT FACILITIES - Estimated construction costs, Provisional Plan A, Annual charges for municipal sewage treatment - Provisional Plan A, Annual charges for private sewage treatment - Provisional Plan A, Annual charges for industrial waste treatment - Provisional Plan A, Estimated construction costs - Provisional Plan B, Annual charges for municipal sewage treatment - Provisional	17

SECTION V - POLLUTION CONTROL (Continued)

Page

Plan B, Annual charges for private sewage
sewage treatment - Provisional Plan B, Annual
charges for industrial waste treatment -
Provisional Plan B, Annual charges for municipal
sewage treatment - Provisional Plan C, Annual
charges for private sewage treatment - Provisional
Plan C, Annual charges for industrial waste
treatment - Provisional Plan C.

17

BENEFITS RESULTING FROM WATER QUALITY IMPROVEMENT -
Power conservation storage and flood control,
Other reservoir and resource development projects.

22

SECTION VI - FLOOD CONTROL AND DRAINAGE

HISTORY AND ANALYSIS OF FLOODS - Flood history, Analysis
of floods.

1

DAMAGES - Headwater flood damage, Main river and lower
tributary flood damage areas, Erosion damages,
Sedimentation damages, Total damages.

1

NEEDS - Basin requirements.

4

PLANS OF DEVELOPMENT - Existing flood control improvements,
Consideration of flood control improvements, Effect
of land treatment program on floods.

4

BENEFITS -

6

SUMMARY AND CONCLUSIONS - Summary

7

DRAINAGE -

7

SECTION VII - POWER DEVELOPMENT

AVAILABLE POWER - Existing developments, The International
St. Croix River Board of Control, Available power.

1

HYDROELECTRIC POWER INVENTORY - Detailed investigation of
rejected sites.

4

SECTION VIII - NAVIGATION

Authorized project, Status of project, Commerce,
Adequacy of the existing project.

1

SECTION IX - FISH AND WILDLIFE

Page

WILDLIFE - Deer, The black bear, Moose, Other forest game, Waterfowl, Fur-bearing animals. 1

FISH - Brook trout, Salmon, Bass, Other fish, Recreational facilities. 5

ECONOMIC ASPECTS - 7

NEEDS AND DEVELOPMENT OF FISH AND WILDLIFE - Control of habitat changes, Fishery resources, Effect of dams, Effect of pollution, Control of warm-water fish, Management of lakes for fishing. 8

COORDINATION WITH OTHER LAND AND WATER DEVELOPMENT - 22

FISH AND WILDLIFE PLAN - 22

SECTION X - RECREATION

THE RESOURCES - Natural features of recreation importance, Historical and archeological features. 1

PRESENT RECREATION USE - General recreation, Private and commercial facilities and accommodations, Public areas and facilities, Estimate of present use. 3

RECREATION NEEDS AND POTENTIALITIES - 5

PLAN FOR DEVELOPMENT OF RECREATION - General discussion of the plan, Benefits of the plan. 9

SECTION XI - LAND MANAGEMENT

SECTION XII - MINERALS

INTRODUCTION - 1

MINERAL COMMODITIES - Sand and gravel, Copper and nickel, Granite, Peat, 3

MINERAL PLAN - 4

SECTION XIII - INSECT CONTROL

PRESENT STATUS OF INSECTS ADVERSE TO PUBLIC HEALTH AND THEIR CONTROL - Disease and vector problem, 1

	<u>Page</u>
SECTION XIII - INSECT CONTROL (Continued)	
Mosquitoes, Black flies, Deer flies and horseflies, Punkies,	1
BENEFITS AND COSTS OF INSECT CONTROL -	8
EFFECTS OF WATER RESOURCES DEVELOPMENTS ON INSECTS -	9
CONCLUSIONS -	12
INSECT CONTROL PLAN -	13
SECTION XIV - COORDINATED BASIN PLAN	
GENERAL DISCUSSION - Storage and stream flow regulation, Water supply, Pollution control, Flood control and drainage, Power development, Navigation, Fish and wildlife, Recreation, Land management, Minerals, Insect control.	1
VIEWS OF LOCAL INTERESTS -	5
FEATURES OF THE COORDINATED BASIN PLAN -	6
APPRAISAL OF THE COORDINATED BASIN PLAN - Water supply, Pollution control, Fish and wildlife, Recreation, Minerals, Insect control.	9
RECOMMENDATION -	12

ST. CROIX RIVER BASIN

LIST OF TABLES

<u>Table</u>	<u>Page</u>
SECTION I - GENERAL DESCRIPTION	
1. Mean monthly and annual temperatures -	9
2. Average precipitation -	10
3. Snowfall -	11
4. Stream flow records -	12
SECTION III - STORAGE AND STREAM FLOW REGULATION	
5. Major storage developments -	1
SECTION IV - WATER SUPPLY	
6. Chemical and physical characteristics of untreated public surface water supplies -	3
7. Summary of known present effects of industrial and municipal pollution on fresh stream water quality -	5
8. Chemical and physical characteristics of untreated public ground water supplies -	8
9. Water used and water supplied -	10
SECTION V - POLLUTION CONTROL	
10. New England Interstate Water Pollution Commission tentative plan for classification of waters -	follows 4
11. Approximate present stream conditions and approximate stream conditions resulting from treatment or disposal under provisional plans -	12
12. Approximate effects of provisional plans on water conditions -	16
13. Summary of estimated construction costs and annual charges for treatment and disposal facilities - Provisional Plans A, B and C -	23
14. Basic data on sources of municipal and industrial pollution -	28

LIST OF TABLES - Continued

<u>Table</u>	<u>Page</u>
SECTION VI - FLOOD CONTROL AND DRAINAGE	
15. Average annual flood, erosion and sedimentation damages -	3
16. Summary of ultimate flood reduction and erosion control benefits incidental to land treatment -	6
SECTION VII - POWER DEVELOPMENT	
17. Existing hydroelectric plants -	2
18. Hydroelectric projects investigated in detail -	6
SECTION X - RECREATION	
19. Estimated costs of recreation development -	12
SECTION XIII - INSECT CONTROL	
20. Approximate densities of important pest species -	5
21. Population centers where insect control programs may be desirable -	6

ST. CROIX RIVER BASIN

LIST OF PLATES

Plate

1. Basin map -

Frontispiece

Follows page

SECTION IV - WATER SUPPLY

- | | |
|---|------|
| 2. Surface water supply - | IV-2 |
| 3. Average weekly air and water temperature - | 4 |
| 4. Expected yield of wells - | 6 |
| 5. Total daily water use - | 10 |

SECTION V - POLLUTION CONTROL

- | | |
|---|-----|
| 6. Approximate present stream conditions - | V-4 |
| 7. Water conditions resulting from Provisional
Pollution Control Plan A - | 18 |
| 8. Water conditions resulting from Provisional
Pollution Control Plans B and C - | 18 |

SECTION VII - POWER DEVELOPMENT

- | | |
|---------------------------|-------|
| 9. Basin map with sites - | VII-7 |
| 10. River profile - | 7 |

SECTION X - RECREATION

- | | |
|-----------------------------------|------|
| 10a. Parks and recreation areas - | X-12 |
|-----------------------------------|------|

SECTION XII - MINERALS

- | | |
|-------------------------------------|----------------|
| 11. Locations of mineral deposits - | (facing) XII-3 |
|-------------------------------------|----------------|

ST. CROIX RIVER BASIN

LIST OF PHOTOGRAPHS

	<u>Follows page</u>
New storage dam on Tomah Stream. This small dam is typical of the type supplying water for pulpwood drives, hydroelectric power and industrial needs.	III-1
The St. Croix River near Baring, Maine. Industrial waste pollution and dams have eliminated sea-run fishes from the basin.	V-1
West Grand Lake Dam obstructs salmon migrations along the West Branch St. Croix River.	IX-11
Salmon spawning and nursery portion of Grand Lake Stream with a Maine State salmon hatchery on its bank.	IX-13
The East Branch St. Croix River downstream from East Grand Lake is an undisturbed stream in a natural setting and is an important spawning area for land-locked salmon.	X-2

SECTION I - GENERAL DESCRIPTION

1. Location and area. - The St. Croix River Basin, as shown on Plate 1, is located in the southeastern corner of Maine and the southwestern portion of New Brunswick, Canada. Its watershed is bounded on the north by the Saint John River Basin, on the west by the Penobscot River Basin, and on the south and east by coastal streams. The basin has a maximum length in a northwest-southeast direction of about 70 miles and a maximum width in a northeast-southwest direction of about 50 miles. Of the total area of 1,635 square miles, 1,010 square miles are in Maine and 625 square miles are in New Brunswick. In the Maine portion of the basin 70 or more lakes and ponds have surface areas totaling over 135 square miles, nearly 13.5 percent of the watershed area in Maine.

2. The St. Croix Basin has the shape of an irregular "Y" stretching across the international boundary between southeastern Maine in the United States and southwestern New Brunswick in Canada. Two chains of lakes and rivers, a northern group and a western group, join near Kellyland and flow southeasterly along the international boundary to Passamaquoddy Bay. The basin's land surface is a gently rolling lowland except for a few hills near its watershed divides which rise over 800 feet.

3. Original or cut-over forests cover most of the basin. Less than one-tenth of its area is in farmland utilized for dairying, poultry farming and blueberry crops in particular.

Products of the forest, the farm, and also the sea provide the raw materials for the economic activities of the population. This population is concentrated in a few communities, nearly all in the lower St. Croix valley.

4. Main river. - The St. Croix River throughout its entire length forms a part of the international boundary between the United States and Canada. The river originates at the outlet of Grand Lake in the Chiputneticook Lake system, at Forest City, Maine, and flows first in a general northerly direction, through Mud Lake, for a distance of about three miles, and then 20 miles southeasterly through Spednic Lake to its outlet near Vanceboro, Maine. From this point the river follows a meandering course in a general southerly direction for about 54 miles to tidewater at Calais, Maine and St. Stephen, New Brunswick. In the 77 miles of its length between the outlet of Grand Lake and mean highwater at Calais the river falls a total of 424 feet. Nine feet of this fall are between Grand and Mud Lakes and 41 feet are between Mud and Spednic Lakes. The remaining 374 feet of fall are in the St. Croix River below Spednic Lake. A profile of the St. Croix River above Calais is shown on Plate 10.

5. The estuary. - The tidewater estuary extends east from Calais and then south for approximately 14 miles to its mouth at Passamaquoddy Bay, between Liberty Point in Robbinston, Maine and Joes Point in St. Andrews, New Brunswick. The mean range of tide at the mouth is 19.2 feet, and at Calais, 20 feet. The

extreme ranges, due to the combined effect of wind and other causes, are 21.8 and 22.8 feet, respectively.

6. Headwater tributaries. - The headwater area of the St. Croix River includes approximately 131 square miles, 79 in Maine and 52 in New Brunswick, that are drained by Monument Brook and the upper portion of the Chiputneticook Lakes. Monument Brook rises in the northeast corner of the town of Amity, Maine and flows in a general southerly direction for about 12 miles to its mouth at North Lake. The river then continues south for about 16 miles to the outlet of Grand Lake at Forest City, Maine.

7. Other tributaries. - The principal tributary drainage area of the St. Croix River is that of the former West Branch, now known as Grand Falls Flowage, in the west-central part of the watershed. The flowage was created by the construction of the Grand Falls dam on the St. Croix River near Kellyland. The headwaters of the Flowage consist of a system of lakes connected by short riverways or narrows. From the uppermost lake, Lombard Lake in the northern part of Lakeville, Maine, the flow is through Upper Sysladobsis, Sysladobsis, Pocumcus, and Pug Lakes to Grand Lake. The latter is the second of two lakes with this name in the basin; the other being located in the headwaters of the main river. From the outlet of Grand Lake the flow falls 95 feet in about three miles down Grand Lake Stream to Big Lake, then through Big, Long, and Lewy Lakes to Grand Falls Flowage,

at an elevation of 203 feet. Tributary to Pug Lake is a chain of lakes including Pleasant, Scraggly, and Junior Lakes which in turn are fed by streams from numerous smaller lakes. The drainage area of the Flowage and its headwater lakes is 67¹/₄ square miles, approximately 67 percent of the total basin area in Maine.

8. The principal tributary to Grand Falls Flowage is Tomah Stream which rises in Tomah Lake four miles northeast of the village of Brookton, Maine and flows in a general southerly direction for about 3¹/₄ miles to its mouth at Grand Falls Flowage. It has a drainage area of 15¹/₄ square miles and a total fall of 339 feet of which about 300 feet are in its upper 12 miles.

TOPOGRAPHY AND GENERAL GEOLOGY

9. Topography. - The St. Croix River Basin is in general a post-maturely dissected lowland with topography which has been considerably modified by glaciation and marine invasion. The extensive lake systems in the basin and the numerous flat or gently rolling plains, both of which are conspicuous features of the region, are to a considerable extent the direct result of glaciation. These features also indicate that erosion of the region had reached the post-mature stage prior to the advent of the last glacier. The lowlands of the basin are everywhere below an elevation of 500 feet. Low hills rise a few hundred feet above the lakes and swampy plains. A few hilltops on the narrow basin watershed and some monadnocks reach elevations of 1,000 to over 1,200 feet.

Musquash Mountain, at an elevation of 1,238 feet, is the highest point in the basin.

10. Bedrock. - The bedrock of the basin consists of Paleozoic rocks including Ordovician and Silurian sediments and volcanics and extensive areas of Devonian granitic and associated igneous rocks. The Ordovician and Silurian rocks have been closely folded into beds that dip steeply with the axes of the folds trending northeast-southwest. The original shales, sandstones and volcanics have been altered to quartzite and argillite, and locally to schist and gneiss. These metamorphic rocks underlie the upper part of the basin, from the northern limits of its watershed to the Chiputneticook Lakes where a large granitic mass borders the lakes and extends toward the southwest. From the outlet of the lakes the river flows across the trend of the sediments until it again reaches granitic rocks near the point between Woodland and Calais where it makes a sharp bend. A small re-entrant of Ordovician rocks crosses the river immediately below Calais, but most of the marine estuary of the St. Croix is cut in granites. The end of the long peninsula occupied by the town of St. Andrews, New Brunswick and a matching area on the United States side at the mouth of the river are underlain by red sandstone and conglomerate which are believed to be upper Devonian in age and hence are the youngest consolidated rocks in the basin.

11. Surficial geology. - The overburden throughout the basin consists of glacial till, aqueo-glacial outwash, and marine sediments. While the glacial till composed of silty, gravelly sand with cobbles and boulders, blankets most of the bedrock in the region, very extensive areas of the till itself have been buried by later glacial outwash and marine materials. Therefore, the till generally is exposed at the surface only on the hills in the basin. Overlying the till in the valleys and broad lowland areas are materials characteristic of deposition by streams flowing on or from the melting glacier. These materials, consisting of sand or sand and gravel, form numerous and extensive outwash plains, deltas, kames and eskers. Many of the flat, swampy plains in the basin are largely the result of grading of material washed out in front of the retreating ice. Among the most prominent of the eskers is one which is very well developed along Tomah Stream. Several eskers are found on the west side of the main river in the vicinity of Spednic Lake, and others occur in the valley of Little Musquash Stream south of Grand Lake and along the shore of Grand Falls Flowage east of Princeton, Maine. Marine clay was laid down on top of the deposits of previous outwash in some of the lowlands as the sea advanced over the land with retreat of the glacier. Deposits of organic materials and peat occupy extensive swampy areas throughout the basin.

MAPS

12. The U. S. Geological Survey has published standard quadrangle sheets covering all the United States area of the watershed at a scale of 1:62,500 and a general map of the State of Maine at a scale of 1:500,000. It has also prepared a series of maps covering the basin area below Woodland, Maine, at a scale of 1:24,000. The Army Map Service has issued a topographic map entitled Calais (NL 19-9), scale 1:250,000 which affords coverage of all the Maine portion of the basin. The Maine area of the basin is also shown on sheets 3 and 4 of the Maine Transportation Maps, scale 1:250,000, issued by the U. S. Bureau of Public Roads. General highway maps prepared by the State Highway Commission in cooperation with the Public Roads Administration (Bureau of Public Roads), showing stream patterns, cultural features and other details, are available for all of the basin area in Maine. The New Brunswick area of the basin is shown on the Fredericton-Moncton Quadrangle of the National Topographic Series, scale 1:506,880, prepared by the Surveys and Engineering Branch, Department of Mines and Resources, Canada.

13. The entire length of the St. Croix River, from the source of Monument Brook to the mouth of the river at Passamaquoddy Bay, is shown on sheets 1 to 15 of a strip map, at a scale of 1:6,000, published in 1924 by the International Boundary Commission. This map covers a strip varying from about 0.5 to 3.5 miles wide along the course of the river.

14. The tidal portion of the river is shown on U. S. Coast and Geodetic Survey Chart No. 801. Areas covered by published geologic maps are shown on a "Geologic Map Index of Maine," dated 1949, at a scale of 1:750,000, which has been published by the U. S. Geological Survey.

CLIMATOLOGY AND HYDROLOGY

15. The St. Croix River Basin has a humid continental climate characterized by cold winters and short, warm summers. "Prevailing westerlies" and the cyclonic storms that cross the country from the west or southwest towards the east or northeast bring most of the precipitation, except for occasional coastal storms.

16. Temperature. - The average annual temperature of the basin is about 41° F. Average annual temperatures for particular areas within the basin range from 42° F. at points near the coast to less than 40° F. in the headwaters. Average monthly temperatures vary widely throughout the year, from between 60° to 67° F. in July and August to between 10° to 20° F. in January and February. Recorded daily temperatures have been as high as 102° F. and as low as minus 41° F. within the basin. The mean monthly temperatures at six cooperative weather stations in or near the basin are summarized in Table 1.

Table 1 - Mean monthly and annual temperatures,
St. Croix River Basin

<u>Station</u>	<u>Within the basin</u>			<u>Near the basin</u>		
	St. Stephen: N.B.	Woodland: Me.	McAdam: N.B.	Eastport: Me.	Houlton: Me.	Woodstock N.B.
<u>Years of record</u>	18	25	21	80	51	25
<u>Elevation (feet, mean sea level)</u>	-	140	459	33	410	134
<u>Month</u>	<u>(Degrees Fahrenheit)</u>					
January	17	17	12	21	12	11
February	17	17	12	22	14	12
March	28	27	25	30	26	25
April	40	40	38	39	39	38
May	51	51	50	48	52	51
June	59	62	59	55	62	61
July	66	67	65	61	65	67
August	63	66	62	61	64	64
September	56	57	55	56	55	56
October	46	47	45	48	45	46
November	35	34	32	37	31	32
December	21	21	17	25	19	18
Annual	42	42	39	42	41	40

17. Precipitation. - The mean annual precipitation over the St. Croix River Basin is about 40 inches. Variations in the amounts of average annual precipitation over various portions of the watershed are small, ranging from about 41 inches over areas in the lower basin to less than 40 inches over areas in the headwaters. The distribution of precipitation is uniform throughout the year. The range between maximum and minimum totals of average monthly precipitation at rainfall stations within the basin

is only about two inches. The totals of average monthly rainfall at McAdam, New Brunswick about six miles east of Vanceboro, Maine, range from a minimum of 2.65 inches in May to a maximum of 4.25 inches in October; at Woodland, Maine from 2.41 inches in February to 4.58 inches in October. The records of precipitation at five cooperative weather stations in or near the basin are summarized in Table 2.

Table 2 - Average precipitation,
St. Croix River Basin

<u>Station</u>	<u>Within the basin</u>		<u>Near the basin</u>		
	Woodland: Me.	McAdam: N.B.	Eastport: Me.	Woodstock: N.B.	St. Andrews N.B.
<u>Years of record</u>	34	21	80	25	19
<u>Elevation (feet, mean sea level)</u>	140	459	33	134	50
<u>Month</u>					
January	3.35	3.44	3.66	3.31	4.92
February	2.41	3.00	3.23	2.49	3.49
March	3.28	3.42	3.61	2.76	3.58
April	3.79	3.39	2.86	2.62	2.75
May	2.61	2.65	2.96	2.69	2.73
June	3.16	3.05	3.06	3.94	3.18
July	2.46	3.07	3.11	3.40	2.78
August	3.12	3.49	3.01	2.99	3.01
September	4.00	3.78	3.04	3.02	3.06
October	4.58	4.25	3.48	3.53	3.70
November	3.62	3.66	3.68	2.80	4.00
December	3.47	3.44	3.54	2.63	3.89
<u>Annual</u>	39.85	40.64	39.24	36.18	41.09

18. Snowfall. - The annual snowfall over the watershed varies from about 70 inches in the southern portion of the basin to nearly 100 inches at inland points. The water content of the snow cover over the entire watershed in the early spring often amounts to three to four inches. A water content of five inches or more is quite common at the higher elevations away from the coast. The average annual snowfall at five locations in the general vicinity of the basin is shown in Table 3.

Table 3 - Snowfall,
St. Croix River Basin

<u>Station in the basin</u>	<u>Elevation</u> (feet, mean sea level)	<u>Years of record</u>	<u>Average annual snowfall</u> (inches)
McAdam, N. B.	459	21	87.0
<u>Stations near the basin</u>			
Eastport, Me. (south)	33	80	71.6
St. Andrews, N.B. (southeast)	50	19	85.1
Harvey, N. B. (northeast)	490	19	97.3
Woodstock, N.B. (north)	134	25	96.9

19. Stream flow records. - The U. S. Geological Survey has published records of stage or flow at five gaging stations that have been in operation in the St. Croix River Basin for various periods of time since 1902. The records at these stations, rated as generally good to excellent, are summarized in Table 4.

Table 4 - Stream flow records,
St. Croix River Basin

Location of gaging station	Drainage area (sq. mi.)	Period of record	Discharge		
			Mean(1)	Maximum(2)	Minimum(2)
(cubic feet per second)					
St. Croix River					
Vanceboro, Me. (7)	435	1928-	663	4,010 (Mar. 23, 1936)	1.9
Baileyville, Me. (3)	1,320	1919-	2,124	23,300 (4) (May 1, 1923)	100 (5)
Woodland, Maine	1,380	1902-11	-	20,300 (5) (Sep. 29, 1909)	50 (5)
Grand Lake Stream					
Grand Lake Stream, Maine	224	1928-	339	2,150	5 (5)
West Branch St. Croix (6)					
Baileyville, Maine	509	1910-12		(Stage only)	

(1) For period of record through September 30, 1951

(2) Instantaneous unless otherwise noted

(3) About 700 feet below power house at Grand Falls Dam, Kellyland

(4) Maximum in 1936 flood was 16,900 cubic feet per second on March 23

(5) Daily

(6) Now Grand Falls Flowage

(7) *Maximum flow at Vanceboro, Maine (1.9) affected by operation of gates in dam upstream*

20. Run-off. - The average annual run-off for the basin is about 22 inches (1.6 cubic feet per second per square mile) or slightly over one-half the average annual precipitation. Monthly variations in run-off, owing to the considerable extent of lake, pond, and swamp area in the watershed, are not great. Slightly over one-third of the annual run-off occurs in the spring months of March, April and May.

SECTION II - ECONOMIC DEVELOPMENT

SETTLEMENT

1. The first settlement in the St. Croix River Basin was made in 1604 when a band of about 80 French colonists under Pierre du Guast, the Sieur de Monts, and Samuel de Champlain established a trading post and settlement on Dochet Island in the St. Croix River about 4.5 miles above its mouth. This settlement lasted less than two years before it was moved to Nova Scotia, but the French continued to use the island occasionally as a garrison for a number of years. This post was destroyed by the English in 1613 and never rebuilt.

2. Calais was first settled in 1779 by Frenchmen who were attracted to the locality by the wealth of timber, the fertility of the soil, and the abundance of fish and game. The settlement soon became an important lumber center. In 1801 the first vessel built at Calais was launched, and for a number of years thereafter shipbuilding proved to be a profitable industry. In 1850, when its population had reached nearly 4,800, Calais was incorporated as a city. Since 1850 Calais and most other settlements in the basin have been dependent on the timber resource.

POPULATION

3. The St. Croix River Basin is sparsely settled with only about 21,400 people in the entire watershed. The 1950 population in the United States portion of the basin, based on recent figures published by the Bureau of the Census, is estimated at approximately 9,400. This represents a decrease of about six percent during the 10-year period between 1940 and 1950. Calais and Baileyville, with

populations of approximately 4,600 and 1,800, respectively, are the two largest communities in the Maine area of the watershed. Together they account for about 68 percent of the total United States population in the basin.

4. The estimated population in the Canadian portion of the basin in 1951, based on Ninth Decennial Census figures compiled by the Dominion Bureau of Statistics, is about 13,000 which represents an increase of approximately 10 percent since 1941. About 55 percent of this population is within the township limits of St. Stephen where there is a population of over 7,100 including over 6,000 in the towns of St. Stephen and Milltown together.

ECONOMY

5. Industry in the basin has been developed only to a small extent. Lumbering and the manufacture of paper and wood products constitute the chief industrial activities in this heavily forested watershed. The production of lumber and wood products and the canning of blueberries are the principal industries in Calais, the commercial center for the United States portion of the basin. The St. Croix Paper Company, one of the largest manufacturers of paper in Maine, is located in Woodland in the township of Baileyville. In addition, the Seaboard Packing Company has a sardine cannery, located in Robbinston.

6. Less than 10 percent of the basin area is devoted to farming.

Among the principal agricultural activities in the basin are dairying, poultry farming, and the harvesting of blueberries. The accommodation of tourists, sportsmen and vacationers attracted to the basin by reason of its extensive forest and lake areas provides an additional source of income for the inhabitants.

TRANSPORTATION

7. This sparsely settled basin contains only a few major highways. U. S. Route 1 traverses the entire length of the basin in a general northwest-southeast direction. It passes through Woodland and Calais, Maine State Highway No. 6, crossing the basin in a general east-west direction, connects Vanceboro and Lincoln and other points in Maine west of the basin.

8. Railroad freight and passenger service to Calais, and freight service from Calais to Woodland, are provided by one line of the Maine Central Railroad. A second line of this company affords freight and passenger service to Vanceboro. Vanceboro is also on a main line of the Canadian Pacific Railway between St. John, New Brunswick and Montreal.

9. Although there is an airfield at Calais, no scheduled flights to points within the basin are maintained by commercial airlines.

SECTION III - STORAGE AND STREAM FLOW REGULATION

1. General. - The flow of the St. Croix River is regulated by several storage dams and lakes, together with the storage of many natural lakes in northern and western sections of the river basin. Storage dams were constructed as early as 1825. More recent major dams built for storage, stream flow regulation, and industrial uses have been the Grand Falls Dam (1925) and Milltown Dam (1934)

2. Existing storage. - The useful storage in the St. Croix River Basin totals approximately 592,450 acre feet (25,806 million cubic feet). This storage is utilized primarily by the St. Croix Paper Company for power and log-driving purposes. Data on the major storage developments within the basin are shown in Table 5.

Table 5 - Major storage developments,
St. Croix River Basin

<u>Reservoir</u>	<u>Drainage</u>	<u>Useful storage capacity</u>	
	<u>Area</u> (square miles)	<u>(acre-feet)</u>	<u>(million cubic feet)</u>
Grand and North Lakes*	146	100,000	4,356
Spednic Lake*	435	202,000	8,799
Sub-total, Chiputneticook Lakes above Vanceboro		302,000	13,155
Sysladobsis Lake	59	31,800	1,385
Grand Lake	224	157,000	6,839
Clifford Lake	-	7,150	311
West Musquash Lake	-	8,500	370
Grand Falls Flowage	1,320	86,000	3,746
Sub-total, Grand Falls Flowage and headwater lakes		290,450	12,651
Total, St. Croix River Basin		592,450	25,806
*International lakes			

3. Operation and regulation. - The St. Croix River is well regulated by existing storage. Records of the U. S. Geological Survey gage located a short distance below the Grand Falls Dam in Baileyville, Maine (see Table 4) reflects the effect of available storage on the flow in the river. The minimum mean monthly flow at this gage since it was placed in operation in November 1919 has been 0.43 cubic feet per second per square mile (573 c.f.s.) in February 1948. By comparison, the minimum mean monthly flow on a nearby tributary with about the same drainage area but with no upstream storage - the Mattawamkeag River with a drainage area of 1,400 square miles in the Penobscot River Basin - has been 0.09 cubic feet per second per square mile.

4. Potential storage. - As described in Section VII, and shown on Plate 9, 23 sites were investigated for storage or power. None were found to be economically feasible for development for water storage or hydroelectric power.



New storage dam on Tomah Stream. This small dam is typical of the type supplying water for pulpwood drives, hydroelectric power and industrial needs. St. Croix River Basin .

SECTION IV - WATER SUPPLY

SURFACE WATER AVAILABLE

1. This section includes inventories of the quantity and quality of surface and ground waters, an inventory of present water supply uses and estimates of future water supply requirements. Polluted surface waters and lack of ground water information are creating problems. Increasing supplemental irrigation could create problems.

2. Safe yield. - Minimum monthly flows for the period from October 1929 to September 1949 were determined from stream gaging records of the U. S. Geological Survey and used as the safe water supply yield of the various streams. These safe yields can be increased by constructing storage reservoirs.

3. The minimum monthly flow or safe yield of the St. Croix River at Calais, Maine, is 392 million gallons per day (605 cubic feet per second) or 0.268 million gallons per day per square mile. This minimum flow occurred during February 1948.

4. Minimum monthly stream flows for the St. Croix River Basin are shown in Plate 2, "Surface Water Supply." Stream flows are taken from gaging stations, where available, and were estimated for other areas by comparison with gaged areas.

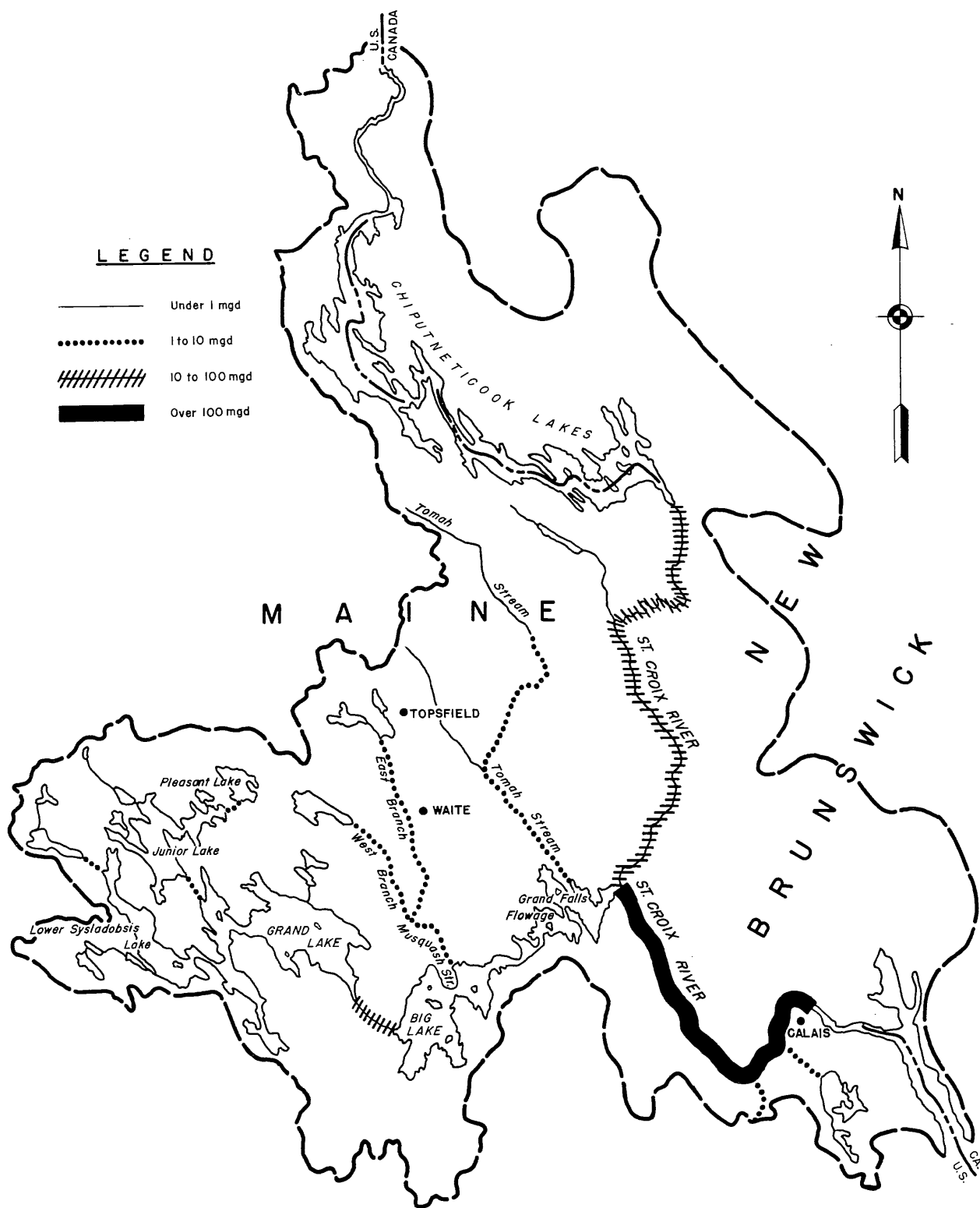
5. The St. Croix River Basin includes 96 miles of streams having safe yields in excess of one million gallons per day as indicated below and as shown on Plate 2, "Surface Water Supply."

<u>Safe yield in million gallons per day</u>	<u>Miles of stream in St. Croix River Basin</u>
Over 100	20
10 - 100	32
1 - 10	44
Total over 1	96

6. There are many miles of streams having significant yields less than one million gallons per day. In addition to the streams, large water supplies could be taken from the many lakes in the region.

7. Natural quality. - The natural surface waters of the St. Croix River Basin are soft, relatively low in suspended material and mineral content, and are generally suitable for domestic, agricultural and industrial uses. Table 6 gives selected physical and chemical characteristics of the untreated water of the Woodland public water supply.

8. The data available on the mineral and physical quality of waters of the principal streams of the St. Croix River Basin are generally adequate to properly define the industrial utility of the water. These data were obtained from the Division of Sanitary Engineering of the Maine Department of Public Health and Welfare, and the Quality of Water Branch of the U. S. Geological Survey. These agencies have continuing programs to supplement information now available.



ST. CROIX RIVER BASIN
 SURFACE WATER SUPPLY
 NEW ENGLAND NEW YORK INTER-AGENCY COMMITTEE
 JUNE 1953
 SCALE IN MILES
 0 4 8

Table 6 - Chemical and physical characteristics of untreated
public surface water supplies - June 1953,
St. Croix River Basin

	Woodland water supply ppm
Color	5
pH <u>1/</u>	5.2
Specific conductance <u>2/</u>	-
Silica (SiO ₂)	-
Turbidity	0
Iron (Fe)	0.08
Calcium (Ca)	4.3
Magnesium (Mg)	0.88
Sodium (Na)	12.6
Potassium (K)	2.9
Carbonate (CO ₃)	-
Bicarbonate (HCO ₃)	-
Sulfate (SO ₄)	27
Chloride (Cl)	4.0
Fluoride (F)	0.07
Nitrate Nitrogen	0.03
Total solids	20
Hardness as CaCO ₃	20
Alkalinity as CaCO ₃	-

1/ No units.

2/ Micromhos at 25° C.

9. The average weekly air temperatures at Woodland, Maine, and the average weekly water temperatures of the St. Croix River at Woodland 1/, Maine, from January 1, 1951 to December 31, 1951, are shown in Plate 3. The maximum and minimum average weekly temperatures are as follows:

<u>Average weekly temperatures</u>	<u>Maximum</u>	<u>Minimum</u>
Air: at Woodland, Maine	70° F	12° F
St. Croix River: at Woodland, Maine	72° F	36° F

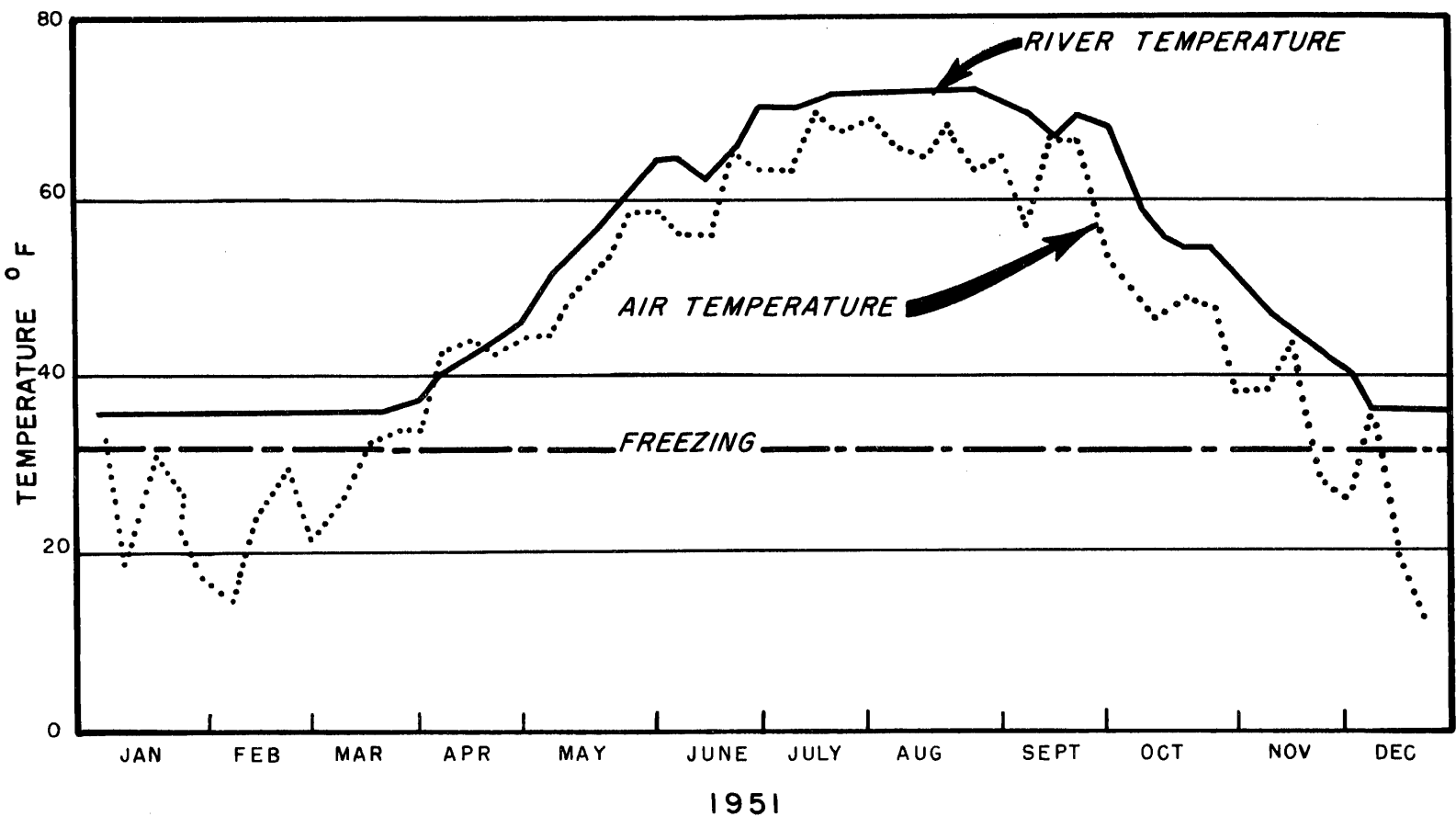
For 24 weeks of the one year period, the average weekly river water temperature was less than the ground water temperature (45° F) which indicates the utility of the river water for cooling purposes.

10. Sanitary quality. - The sanitary quality of the surface waters is shown in Plate 6, "Approximate Present Stream Conditions," and is summarized in Table 7, "Summary of known present effects of industrial and municipal pollution on fresh stream water quality in the St. Croix River Basin."

11. The 71 miles of Conditions I and II water are widely scattered through this basin. The nine miles of Condition III water are in the St. Croix River just upstream of Passamaquoddy Bay. The 16 miles of Condition IV water extend from Woodland to below Calais.

1/ Air temperatures from U. S. Weather Bureau Station at Woodland, Maine.

The St. Croix River temperatures courtesy of the St. Croix Paper Company, Woodland, Maine.



NOTE:

*Air temperature at Woodland, Maine.
St. Croix River temperature at Woodland, Maine.
(courtesy of St. Croix Paper Co.)*

ST. CROIX RIVER BASIN
AVERAGE WEEKLY AIR AND
WATER TEMPERATURES
NEW ENGLAND NEW YORK INTER-AGENCY COMMITTEE
JUNE 1953
SCALE AS SHOWN

Table 7 - Summary of known present effects of industrial and municipal
pollution on fresh stream water quality - June 1953,
St. Croix River Basin

Condition	Suitable for water supply uses	Degree of pollution	Miles of 1/ streams in basin
I	Suitable for all water supply uses. Use as domestic water supply may require disinfection.	None	71
II	Suitable for practically all public water supply after filtration and disinfection, for industrial uses* without treatment, for agricultural uses and for irrigation of crops.	Not appreciable	-
III	Suitable for most industrial uses* without treatment and for irrigation of crops consumed after cooking.	Slight Moderate	9
IV	Suitable for some industrial uses* without treatment.	Severe	16
V	Suitable for no water supply uses.	Gross	None

* Quality requirements for industrial water vary widely. Condition I water may require treatment for some industrial uses. Condition IV water is used without treatment for some industries requiring low quality water. As water conditions decrease from I to IV, it becomes suitable for fewer industrial uses or becomes more difficult to make suitable by treatment.

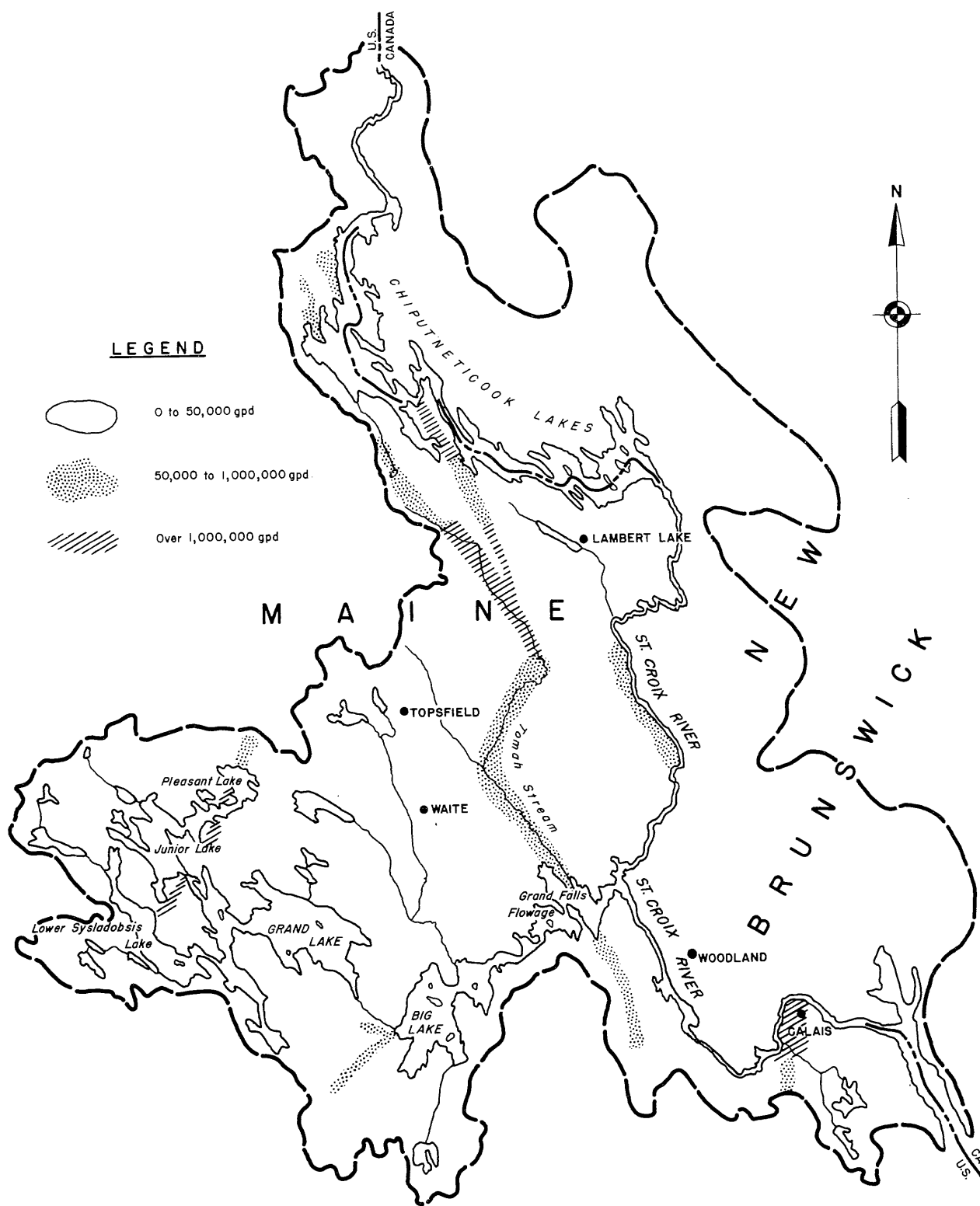
1/ With yields greater than one million gallons per day.

GROUND WATER AVAILABLE

12. Source of information. - A reconnaissance study of the ground water resources of the St. Croix River Basin was made by the Ground Water Branch of the U. S. Geological Survey. From the interpretation of geological maps of this basin and field investigations, areas of significant ground water yield were determined, which are discussed below and are indicated on Plate 4.

13. As there is a tremendous amount of surface water available in the St. Croix River area, there have not been any large ground water supplies developed. Furthermore, it is not likely that any such supplies will be developed in the near future which would furnish complete information on the availability of water from underground sources.

14. Ground water in limited quantities may be found almost anywhere in this basin. However, in some locations, the ground water is not adequately developed to supply at all times the rural homes and farmsteads which have complete plumbing facilities. In general, the yield from wells 100-200 feet deep in bedrock will average 5-12 gallons per minute, but in some areas wells approximately 600 feet deep will yield as high as 80 gallons per minute. The wells developed in till will yield only enough for rural homes and farmsteads and in times of prolonged drought may go dry. The higher yielding wells are located in various types of deposits consisting of sands and gravels.



ST. CROIX RIVER BASIN
 EXPECTED YIELD OF WELLS
 NEW ENGLAND NEW YORK INTER-AGENCY COMMITTEE
 JUNE 1953

SCALE IN MILES
 0 4 8

15. Quality. - The ground waters in this basin are somewhat harder and contain higher concentrations of minerals and suspended materials than the surface waters, but are suitable for domestic, industrial and agricultural uses.

16. Table 8, "Chemical and physical characteristics of untreated public ground water supplies in the St. Croix River Basin," gives the physical and chemical characteristics of the untreated water of the Calais water supply.

17. Sanitary quality of ground water taken from properly constructed wells which are located a safe distance from sources of pollution is satisfactory.

WATER USE

18. Water uses considered are domestic, industrial and agricultural. "Domestic" includes water used by commercial establishments such as stores, hotels, restaurants and markets, as well as water used for bathing, cooking, washing, cleaning and other household purposes. "Industrial" includes process water, cooling water and boiler feed along with other miscellaneous industrial water uses. "Agricultural" water is used for stock watering, irrigation and other miscellaneous agricultural water uses.

19. Rural and agricultural water use. - Rural domestic water supplies and agricultural water supplies depend on many small sources. In general, they have little effect on the available water supply, are not affected by other water supply requirements,

Table 8 - Chemical and physical characteristics of untreated
public ground water supplies - June 1953,
St. Croix River Basin

	Calais water supply ppm
Color	5
pH <u>1</u> /	6.2
Specific conductance <u>2</u> /	-
Silica (SiO ₂)	-
Turbidity	0
Iron (Fe)	0
Calcium (Ca)	5.3
Magnesium (Mg)	0.79
Sodium (Na)	2.0
Potassium (K)	0.60
Carbonate (CO ₃)	-
Bicarbonate (HCO ₃)	-
Sulfate (SO ₄)	4.2
Chloride (Cl)	1.0
Fluoride (F)	0.08
Nitrate Nitrogen	0.12
Total solids	36
Hardness as CaCO ₃	29
Alkalinity as CaCO ₃	-

1/ No units.

2/ Micromhos at 25° C.

and are important in the basin water supply picture only when a significant amount of water is used for irrigation.

20. The private rural water systems supplying domestic and agricultural water serve 2,600 persons including an unknown number of farms. These systems number approximately 650 and supply approximately 0.20 million gallons per day of ground water for all rural water use except irrigation. Each system supplies 300 gallons per day on the average. Approximately 345 (53 percent) of the rural systems are inadequate for domestic water supply in this basin. In addition to the rural water supplies which are inadequate for domestic water supplies, some are inadequate for livestock watering and spraying.

21. The amount of water used for irrigation in this basin is unknown. Estimates indicate that this water use is not significant at the present time. Irrigation is a consumptive use of water. Present irrigation practices probably result in all of the irrigation water being lost to other water uses by evapo-transpiration. The number of farms now wishing to irrigate and unable to secure water for that purpose is unknown but probably small.

22. Plate 5, "Total Daily Water Use" gives an indication of the distribution of total daily water use in million gallons per day throughout the basin. Additional data are given in Table 9, "Water used and water supplied." Significant amounts of water are used in

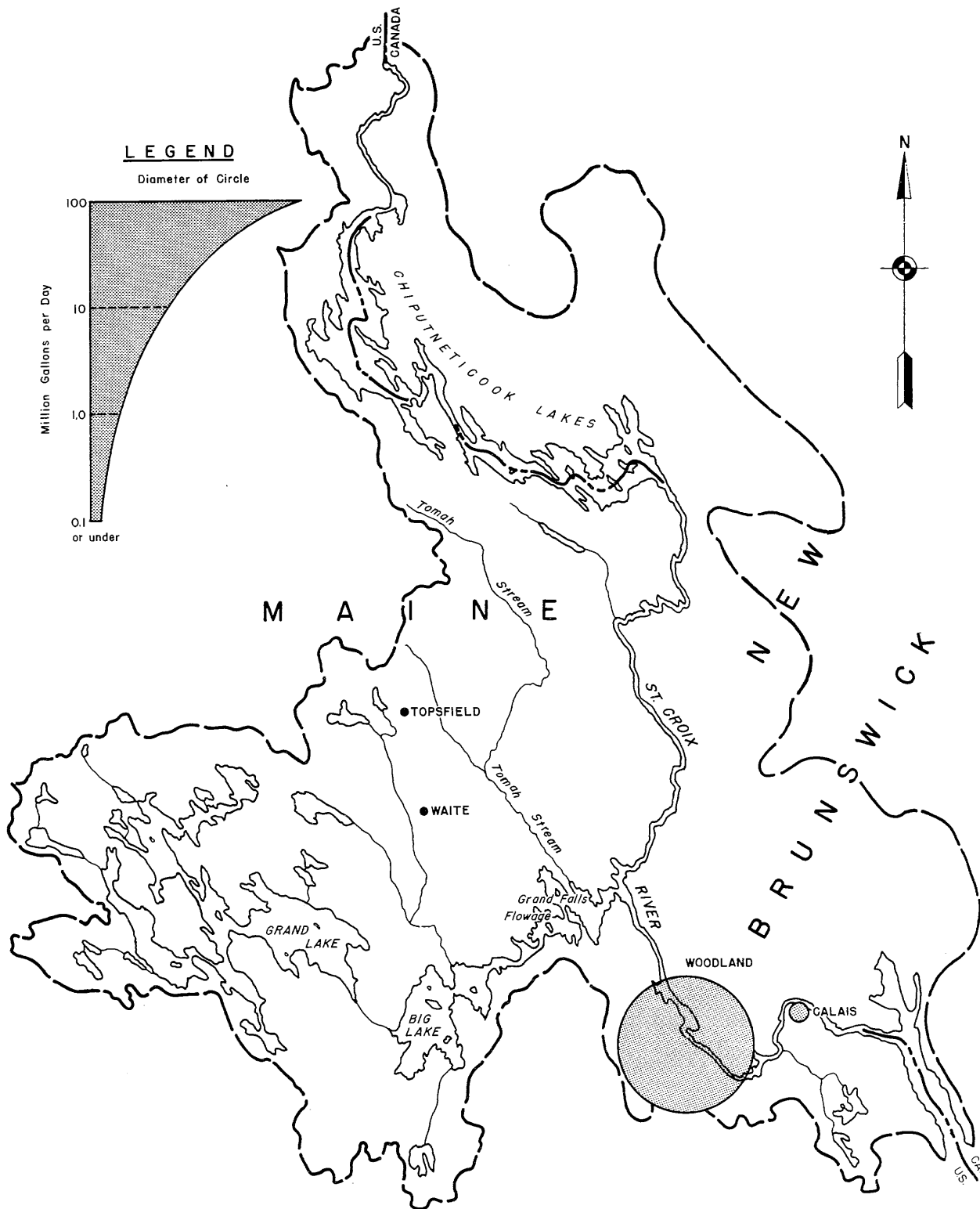
Table 9 - Water used and water supplied - June 1953,
St. Croix River Basin

Name	Water used				Municipal water supply						Private industrial water supply			
	Total	Domestic	Industrial	Source	Treatment*	Population served	Total	Domestic uses	Industrial uses	Total	Surface sources (fresh)	Ground sources	Saline water	
St. Croix River Basin	mgd	%	%				mgd	%	%	mgd	%	%	%	
Calais	0.550	77.1	22.9	Ground surface 2/	Dh P Frs Dh 2/	8,000 1/	0.550	77.1	22.9	-	-	-	-	
Woodland	40.088	0.5	99.5	Surface	P Ca Fps Kp Dc	1,800	0.200	100.0	0.0	39.888	100.0	0.0	0.0	

- * Ca - Chemical dosage for coagulation or softening with alum.
 Dc - Disinfection with chlorine gas.
 Dh - Disinfection with hypochlorite.
 Fps - Filter pressure (sand).
 Frs - Filter gravity (rapid sand).
 Kp - Chemical dosage for corrosion control or water stabilization by alkali feed for pH adjustment.
 P - Purification plant

1/ Includes 3,000 in Milltown, New Brunswick.

2/ Auxiliary supply.



ST. CROIX RIVER BASIN
TOTAL DAILY WATER USE
NEW ENGLAND NEW YORK INTER-AGENCY COMMITTEE
JUNE 1953

SCALE IN MILES
0 4 8

two towns and cities, some of which is supplied by municipal water systems and some by industries. Approximately 99 percent of the total fresh water used in this basin is utilized in Woodland, Maine, which uses a total of 40.09 million gallons per day for both domestic and industrial purposes.

23. Industrial water use. - Total industrial fresh water use in this basin is divided as follows:

- a. Process water, 17.27 million gallons per day (43%)
- b. Cooling water, 21.68 million gallons per day (54%)
- c. Boiler feed, sanitary, service, etc., 1.06 million gallons per day (3%)

Total - 40.01 million gallons per day.

24. Industrial fresh water use may also be divided by type of products as follows:

- a. Wood and wood products, 39.93 million gallons per day (99.8%)
- b. Processing of food products, 0.08 million gallons per day (0.2%)

25. Surface water use. - Of the 40.64 million gallons per day total fresh water used in the basin, 40.09 million gallons per day come from surface sources. One public system obtains water from surface sources and supplies a total of 0.20 million gallons per day. The remaining 39.89 million gallons per day are supplied and mostly utilized by industry.

26. Ground water use. - There are 0.55 million gallons per day of ground water used in this basin. One public water system supplies 0.55 million gallons per day. Industry has no ground water supplies.

27. Reuse. - Industrial and domestic water is used, not consumed and becomes available to other water users immediately after a given industry or municipality has discharged it, except where industries or towns are located on the coast and discharge the used water directly into the ocean. Even when the entire flow of a stream is taken for a water supply, it is usually returned to the stream within a short distance. It then becomes available for reuse, provided the quality of the water is satisfactory for the intended uses. In this basin, the stream waters are in Condition IV below both communities from which used domestic or industrial waters are discharged. Condition IV waters are "severely" polluted and are unsuitable for domestic and most agricultural and industrial uses.

DISCUSSION OF FUTURE WATER RESOURCES

28. Trends in water use. - Trends in water use give a basis for estimating future water use. The prediction of domestic water use depends chiefly on the population to be served. Industrial water use trends are more difficult to predict since technological changes or the addition or loss of one significant water using industry can markedly change water use even though population and employment do not change. Agricultural water use may increase markedly if irrigation becomes widely practiced.

29. The trends for New England and for Maine populations have been studied. The trends indicate that, in the year 2000, population may range from 1.27 to 1.29 times the present. An optimistic conclusion has been drawn that in the year 2000 municipal water use may be as great as two times the present water use.

30. Future availability of water. - Even with this increase, there will be a great surplus of water available in this basin at least to the year 2000. This great surplus of water would support new wet industries if transportation, public utilities, labor and other essentials could be provided.

31. A comparison of total water use to water available will indicate the scarcity or abundance of water at the present and in the future. The ratio of the river water available to total fresh water use in the Woodland area is 19 to 1. As previously mentioned, approximately 99 percent of the total fresh water used in this basin is utilized in this area. Therefore, the ratio of total water use to water available in most other sections of this basin would be even greater than in the Woodland area. These comparisons indicate a great surplus of water available even if the total water use increased two times by the year 2000.

32. Future quality. - The quality of the water in the future will depend on the action taken to maintain or improve the present water condition by control of municipal and industrial pollution and perhaps by improved land use practices to control erosion.

CONTROL OF RESERVOIRS FOR PUBLIC WATER SUPPLIES

33. Control of reservoirs exclusively for public water supply purposes is not practiced in this basin.

CONCLUSIONS

34. It is concluded that:

a. A great surplus of water will be available for water supply in this basin for at least the next 50 years on the basis of needs now foreseeable. Most of this surplus will probably be surface water.

b. The surplus of water available in this basin is a valuable natural resource and could be attractive to new industries having large water demands.

c. The natural surface waters of this basin are relatively soft, have a low mineral content and are slightly acidic. They are suitable for all general water supply uses.

d. The present quality of 16 miles of the fresh surface waters in this basin is impaired for most water supply uses by discharges of sewage and industrial wastes, and nine miles have been impaired for some water uses. There are 71 miles of fresh surface waters that are essentially unaffected. The quality of the fresh surface waters will deteriorate further if waste treatment is not provided to control increased waste discharges, if present wet industries expand or if new wet industries move into the area.

e. The practice of using reservoirs for public water supplies to the exclusion of other uses is not practiced in this basin and, therefore, causes no interference with other water uses.

f. Data for the quality of surface waters in this basin are adequate to define the general usefulness of the untreated water.

g. Ground water is available throughout the basin in small quantities which can be developed to meet the needs of individual rural homes and farms for domestic and agricultural use, except irrigation.

h. The ground waters of this basin are somewhat harder and have higher mineral content than the surface waters, but are generally suitable for many water supply uses as taken.

i. A sharp increase in agricultural water use for supplemental irrigation could significantly reduce the water available in small watersheds, especially during dry, hot weather.

j. The domestic water supply requirements of rural families have little effect on the available water supply in this basin and, in general, are not affected by other water supply requirements. However, the water supply needs of the rural families are very important.

k. Approximately 53 percent of the 650 ground water supplies developed by rural families are not adequate to meet the demands for domestic and agricultural water, with no allowance for irrigation.

WATER SUPPLY PLAN

35. Improvement of water quality. - Pollution control measures described in Section V would improve the quality of deteriorated stream water. These improvements include making the water quality attractive to industry where increased industrial use is desirable. The water supply needs of industry were considered in formulation of the pollution control plan. In addition, farmers and rural residents using surface and ground waters need investigations to point out sources of supply.

36. Investigation of supplemental irrigation. - A study of supplemental irrigation should be made to determine when water used for irrigation purposes has increased so as to threaten to affect other water uses. The study would include the annual collection of data on the acreage irrigated, the amount of water used, the sources of water and the types of crops irrigated. Assuming collection of data by existing agricultural field staffs and organizations, it is estimated that the services of one man, part-time, would be required to analyze data and coordinate field activities. The estimated annual cost of the investigations is approximately \$500.

37. Ground water investigations. - To determine the ground water potential of the St. Croix River Basin comprehensive areal studies of the ground water resources should be made throughout the entire basin. A comprehensive study of this nature includes mapping the surficial and bedrock geology of the area as needed to

delineate roughly the areal extent of the water-bearing formations. In addition, collection and evaluation of subsurface data such as records of wells, test borings, springs, their logs and yields, are needed to aid in determining the thickness of the aquifers, their potential yields, and the quality of the water. This type of study should outline areas favorable for large supplies of water and indicate where only small supplies are available but which usually are sufficient for the needs of consumers of small quantities of water, such as domestic use. It will also indicate a sound basis for development of dependable ground water supplies at a minimum of cost by rural residents and farmers.

38. A preliminary estimate of the cost of the studies needed to evaluate properly the availability of ground water for public supply, industry, and domestic use is about \$10,000. The work involved will require about one man year, which includes field work, preparation of and publication of one report for the entire basin.

SECTION V - POLLUTION CONTROL

1. This section presents an inventory of the effect of pollution on present water conditions, pollution prevention measures in effect, and stream classifications legally adopted for best use of the water resources. In lieu of legal classification of streams transporting pollution which would define the pollution control measures needed to permit the best use of the water resources, three provisional plans are presented. Each provisional plan is evaluated as to its effect on water quality control under the treatment measures shown.

POLLUTION CONTRIBUTED TO WATER RESOURCES

2. There are only four known significant sources of pollution in the basin, three caused by the discharge of untreated municipal sewage and one by untreated industrial wastes.

3. Sewage pollution. - The city of Calais discharges municipal sewage from a connected population of 4,590 persons, the town of Baileyville the sewage from about 1,370 persons in the village of Woodland, and the town of Robbinston the sewage from about 100 persons served by private sewers.

4. Industrial waste pollution. - The only significant source of industrial waste pollution is from a large pulp and paper mill in Baileyville. This plant discharges untreated waste sulfite liquor, groundwood pulp and paper mill wastes computed to have a

population equivalent of approximately 210,000 persons when all units are in operation.

5. Although not counted as a source of pollution in this report, St. Stephen, New Brunswick, discharges untreated sewage from about 5,000 persons into the main stem of the river across from Calais, Maine. This source of pollution also contributes to the present water conditions downstream.

EFFECTS OF POLLUTION ON PRESENT WATER CONDITIONS

6. There is relatively little pollution in the St. Croix River Basin and the effect on the whole of the water resources has been very small. Known significant pollution has been confined to the main stem of the river from the village of Woodland to the ocean.

7. St. Croix River below Woodland. - The untreated municipal sewage and the pulp and paper mill wastes entering the river at Woodland and Calais cause an appreciable deterioration of the water quality. During critical periods, the main stem of the river from Woodland to a point about five miles below Calais, a distance of about 16 watercourse miles, is seriously affected by these wastes and the water is unsuitable for many water uses. Although used by the city as an auxiliary water supply, the Maine Department of Health and Welfare reports that the water quality is not satisfactory for this purpose. Over this stretch the water condition during low flows and elevated temperatures is approximately



The St. Croix River near Paring, Maine. Industrial waste pollution and dams have eliminated sea-run fishes from the basin. St. Croix River Basin .

equivalent to a quality generally acceptable for transportation of the present pollution load without nuisance, power development, navigation and some industrial purposes.

8. St. Croix River below Calais. - From a point about five miles below Calais to the mouth, a watercourse distance of about ~~seven~~^{nine} miles, the water becomes suitable for higher uses. Over this reach of the river after some self-purification and the dilution afforded by tidal action, the water condition is approximately equivalent to a quality generally satisfactory for such uses as recreational boating, game fishing and other purposes not requiring a high water quality or not limited by salinity.

9. Other water resources. - All other water resources in the basin, including the Grand Lakes and others, receive no pollution or are unaffected by very minor or natural pollution. These waters are of very high quality, suitable for all water uses.

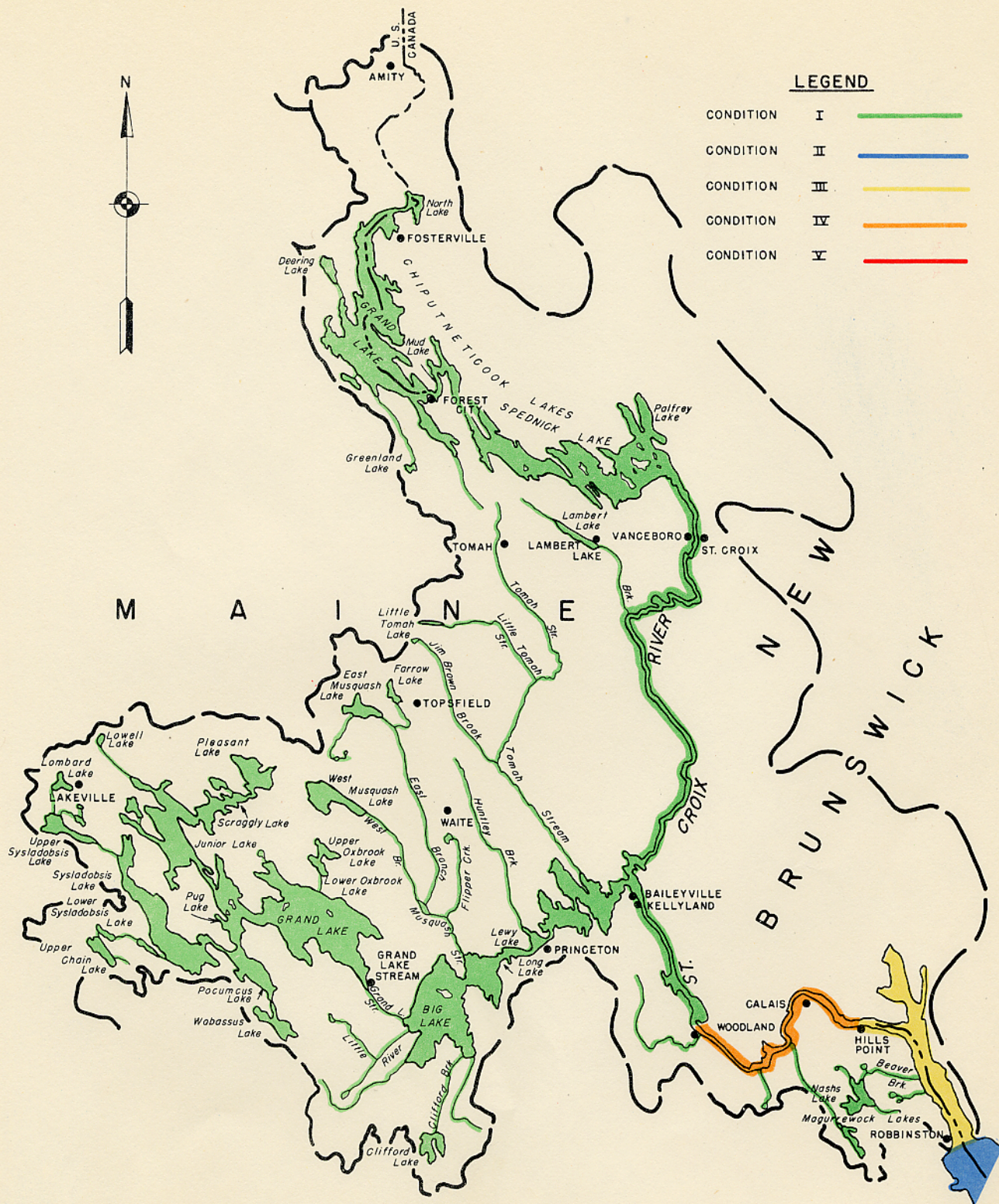
10. The discussion of existing water conditions above are presented more graphically in Plate 6. The miles of watercourse shown represent the approximate reaches of streams affected or unaffected by pollution during periods of low flows that are exceeded 95 percent of the time. Water qualities are expressed in terms of the tentative water quality standards of the New England Water Pollution Control Commission which have been adopted for this purpose. All of the water uses shown may not be made or contemplated at the present time and their presentation is intended

solely to describe the relative effect of existing pollution on present water qualities. Water Conditions I through V are approximately equivalent to Classes A through E of the interstate standards which are reproduced in Table 10.

POLLUTION PREVENTION MEASURES IN EFFECT

11. Treatment facilities. - None of the four known significant sources of pollution in the St. Croix River Basin has been provided with any degree of treatment but are discharged directly to water-courses.

12. Maine State pollution control legislation. - In 1941 the Maine Legislature enacted the Sanitary Water Board Law which was amended in 1945, 1947 and 1949. This law was inadequate to enforce pollution abatement inasmuch as it was, in effect, a limited licensing law. In 1951 the Legislature repealed and replaced Section I of the Revised Statutes, Chapter 72, and created the Water Improvement Commission which replaced the Sanitary Water Board. In 1953 Chapter 72 was further revised and provisions made for standards of classification, classification procedure and enforcement of classifications adopted and other regulations included in the Act. The Water Improvement Commission is directed to make studies, investigations and recommendations to persons responsible for conditions of pollution in the waters of the State as to ways and means such pollution may be controlled in the public interest. The Commission shall make recommendations to each Legislature with respect to the classification



**ST. CROIX RIVER BASIN
 APPROXIMATE PRESENT STREAM CONDITIONS
 DURING CRITICAL PERIOD**

NEW ENGLAND NEW YORK INTER-AGENCY COMMITTEE

DECEMBER 1952

SCALE IN MILES



TABLE 10-
ST. CROIX RIVER BASIN
NEW ENGLAND INTERSTATE WATER POLLUTION CONTROL COMMISSION
TENTATIVE PLAN FOR CLASSIFICATION OF WATERS
(As Revised and Accepted December 8, 1950)

	CLASS A	CLASS B	CLASS C	CLASS D
SUITABILITY FOR USE				
	Suitable for any water use. Character uniformly excellent.	Suitable for bathing and recreation, irrigation and agricultural uses; good fish habitat; good aesthetic value. Acceptable for public water supply with filtration & disinfection.	Suitable for recreational boating, irrigation of crops not used for consumption without cooking; habitat for wildlife and common food and game fishes indigenous to the region.	Suitable for transportation of sewage and industrial wastes without nuisance, and for power, navigation and other industrial uses.
STANDARDS OF QUALITY				
Dissolved oxygen	Not less than 75% sat.	Not less than 75% sat.	Not less than 5 p.p.m.	Present at all times.
Oil and grease	None	No appreciable amount	Not objectionable	Not objectionable
Odor, scum, floating solids, or debris	None	None	None	Not objectionable
Sludge deposits	None	None	None	Not objectionable
Color and turbidity	None	Not objectionable	Not objectionable	Not objectionable
Phenols or other taste producing substances	None	None	None	
Substances potentially toxic	None	None	Not in toxic concentrations or combinations	Not in toxic concentrations or combinations
Free acids or alkalies	None	None	None	Not in objectionable amounts
Coliform bacteria	*Within limits approved by State Department of Health for uses involved	Bacterial content of bathing waters shall meet limits approved by State Department of Health and acceptability will depend on sanitary survey.		

* Sea waters used for the taking of market shellfish shall not have a median coliform content in excess of 70 per 100 ml.

NOTE: Waters falling below these descriptions are considered as unsatisfactory and as Class E.
These standards do not apply to conditions brought about by natural causes.
For purpose of distinction as to use, waters used or proposed for public water supply shall be so designated.

of the rivers, waters and coastal flats based on the classification standards provided in Section I-A.

13. Although Section I of the Revised Statutes, Chapter 72, stipulates that the Commission may employ, subject to provisions of the personnel law, such employees and consultants as needed to carry out the provisions of this chapter, the Commission does not at present have adequate personnel or funds to carry out needed studies and investigations nor for public information programs.

CLASSIFICATIONS ADOPTED FOR BEST USE OF WATER RESOURCES

14. In 1953 the Maine Legislature classified all tributaries of the St. Croix River, the drainage areas of which are wholly within the State, and including the West Branch of the St. Croix River and its tributaries which enter through Grand Lake Flowage, as Class A waters. Under Maine law Class A is the highest classification and shall be kept in a quality suitable for bathing and for public water supplies after disinfection, the dissolved oxygen content shall not be less than 75 percent of saturation and such waters shall contain not more than 100 coliform bacteria per 100 milliliters. No discharge of sewage or other wastes into Class A waters is permitted nor deposits of such material on the banks of these waters in such a manner that transfer of the material into the waters is likely. Class A waters may be used for log-driving or other commercial purposes which will not lower their classification.

PROVISIONAL POLLUTION CONTROL, COSTS AND BENEFITS

15. Inasmuch as classifications have not been adopted for the main stem of the river, the only watercourse receiving significant pollution, the Maine Water Improvement Commission reports that pollution control measures that may finally be required in the St. Croix River Basin cannot be determined at this time.

16. Purpose of provisional pollution control plans. - In lieu of a recommended program for pollution control by the Maine Water Improvement Commission and in order for this report to be as full and comprehensively factual as possible, three provisional plans for pollution control are presented. These provisional plans show (1) the water quality improvement that should result from the pollution control measures shown, (2) the approximate over-all costs for sewage and industrial waste treatment under each provisional plan and (3) the benefits that could accrue from the water quality improvement shown for these plans.

17. Elements of provisional plans. - Hereinafter in this section these three provisional plans will be referred to as Provisional Plans A, B and C. The essence of each plan is as follows:

Provisional Plan A is based on the provision of primary treatment for the two larger sources of sewage pollution and an equivalent or similar degree of treatment for the one source of industrial waste pollution. Subsurface disposal is shown for the sources of sewage pollution from private outlets in Robbinston.

Provisional Plan B is based on the provision of secondary treatment for each of the two larger sources of sewage pollution and an equivalent or substantial degree of treatment for the industrial waste pollution. Subsurface disposal systems are again shown for pollution in Robbinston.

Provisional Plan C is based on the provision of primary treatment at Calais and Baileyville, subsurface disposal of sewage at Robbinston and a substantial degree of treatment of the pulp and paper mill wastes. These degrees of treatment would result in approximately the same improved water conditions as are estimated would result from Provisional Plan B.

18. All plans would provide for the chlorination of sewage effluents. Also, all plans assume that the source of sewage pollution from the Canadian side of the river would be provided with the same degree of treatment as shown for sources on the American side. This is assumed in order to show water quality improvement that could result from the treatment measures outlined in the provisional plans.

19. The science of sewage and industrial waste treatment is too complex to lend itself readily to exact definitions but for the purposes of this section, primary treatment of wastes is interpreted as the process by which, in a series of devices and structures, approximately 30 to 50 percent of the significant polluting materials is removed. Secondary treatment is interpreted as primary treatment plus such additional treatment as

would result in an overall reduction of significant polluting materials of 60 percent or more.

20. Cost estimate criteria. - All cost estimates that follow in this report have been adjusted to the 1949 Engineering News-Record construction cost index. In computing annual charges for provisional pollution control projects, an interest rate of 2-1/2 percent and an amortization period of 30 years have been taken for all public construction. For private construction, annual charges have been computed for an amortization period of ten years at four percent interest. Included in public construction are all projects that would be financed by public funds and private construction includes all projects that would be financed by private capital.

21. Water condition criteria. - Subsequent discussion of water conditions in this report is based on (1) the "Tentative Plan for Classification of Waters" of the New England Interstate Water Pollution Control Commission (as revised and accepted December 8, 1950) and (2) stream flows exceeded 95 percent of the time. In the absence of quantitative data on stream velocities, temperatures, reaeration coefficients and other self-purification factors below individual sources of pollution, these data have been estimated. Reference is made to Table 10, which is the "Tentative Plan for Classification of Waters" for description of the suitability of the classifications of waters for use.

Condition I would approximately correspond to Class A, Condition II to Class B, Condition III to Class C, etc.

22. The provisional plans presented in this section are not conceived to be the most feasible or desirable plans for controlling pollution in the St. Croix River Basin. Such plans can be determined only after best use has been determined and classifications adopted by the State Legislature. Neither are the methods of treatment or disposal shown necessarily the only methods available to produce a similar reduction in pollution. The provisional plans are designed to present sufficient data to judge the benefits and costs of pollution control in the St. Croix River Basin and to serve as a guide in planning water resource development.

PROVISIONAL TREATMENT OR DISPOSAL FACILITIES

23. Treatment facilities--Provisional Plan A. - Provisional Plan A would provide for primary treatment of municipal pollution at Calais and Woodland contributed to by a combined population of 5,960 persons; subsurface disposal for sources of sewage pollution from about 100 persons served by private outlets in Robbinston; treatment of industrial waste pollution; and coagulation and sedimentation or mentation or flotation for paper and groundwood pulp wastes and storage lagoons for waste sulfite liquors. Waste sulfite liquors would be stored until discharge during favorable periods of high run-off or during periods of normal run-off and low temperatures.

24. Reduction of pollution--Provisional Plan A. - These pollution control measures would result in a reduction of the present pollution load of a population equivalent of approximately 19,100 persons, about nine percent of the total. Sewage treatment would account for a reduction in population equivalent of some 8,500 persons and industrial waste treatment about 10,600 persons.

The reduction in pollution load is small because storage of the waste sulfite liquors would result in only minor reduction of the polluting characteristics of this waste, although its regulated discharge during favorable periods would have a very significant effect in improving receiving water conditions for higher uses.

25. Treatment facilities--Provisional Plan B. - Provisional Plan B would provide secondary sewage treatment works at Calais and Woodland, subsurface disposal of the private sewage in Robbinston and for the industrial wastes, coagulation and sedimentation or flotation of paper and groundwood pulp mill wastes and evaporation of concentrated waste sulfite liquors.

26. Reduction of pollution--Provisional Plan B. - These pollution control facilities would result in a reduction of the present pollution load of a population equivalent of an estimated 170,000 persons, about 80 percent of the total. Sewage treatment would produce a reduction in population equivalent of some 5,000 persons and the industrial waste treatment about 165,000 persons. The reduction in present pollution would be large because

evaporation of the waste sulfite liquor discharged in Woodland would eliminate a population equivalent of nearly 157,000 persons, more than 70 percent of the basin total.

27. Treatment facilities--Provisional Plan C. - Provisional Plan C would provide for primary sewage treatment facilities at Calais and Woodland, subsurface disposal of the sources of private sewage in Robbinston and the same treatment facilities for the source of industrial waste as shown above under Provisional Plan B.

28. Reduction of pollution--Provisional Plan C.-- This degree of sewage and industrial waste treatment should result in a reduction in population equivalent of the present pollution load of an estimated 167,000 persons, about 78 percent of the total. Of this reduction, a population equivalent of 2,500 persons would be contributed by sewage treatment and 165,000 by industrial waste treatment. As under Provisional Plan B, the predominating factor is the evaporation of strong waste sulfite liquors which has a population equivalent computed to be nearly 157,000 persons.

29. The details of these three provisional plans are given for each source of pollution in Table 11 which includes data on approximate present water conditions above and below the source of pollution and those which should result from the treatment shown.

Table 11 - Approximate present stream conditions and approximate stream conditions resulting from treatment or disposal under provisional plans, St. Croix River Basin

		: Approximate:		: Approximate	
Sources of pollution:		: present	: Type of treatment	: resulting	
(all discharged to	: Type of	: stream	: or disposal	: stream	
main stem	: wastes	: conditions	: (includes chlorination;	: condi-	
St. Croix River)	: discharged:	above:	below:	of sewage effluents)	: tion

PROVISIONAL PLAN A

Baileyville town					
--Woodland	Sewage (municipal)	I	IV	Primary	III
--Pulp and paper mill	Sulfite and groundwood pulp, paper	I	IV	Coagulation, sedimentation or flotation for paper and groundwood pulp mill wastes; storage lagoons with regulated discharge for waste sulfite liquors.	III
Calais city	Sewage (municipal)	IV	IV	Primary	III 1/
Robbinston town	Sewage (private sewers)	III	III	Subsurface disposal	II

PROVISIONAL PLAN B

Baileyville town					
--Woodland	Sewage (municipal)	I	IV	Secondary	III 2/
--Pulp and paper mill	Sulfite and groundwood pulp, paper	I	IV	Coagulation, sedimentation or flotation for paper and groundwood wastes; evaporation of waste sulfite liquors.	III 2/
Calais city	Sewage (municipal)	IV	IV	Secondary	III 2/
Robbinston town	Sewage (private sewers)	III	III	Subsurface disposal	II

Table 11 (continued)

Sources of pollution: (all discharged to main stem St. Croix River)	Type of wastes	:Approximate: present	Type of treatment or disposal	:Approximate resulting
		stream		stream
		conditions	(includes chlorination	condi-
		discharged:above;below;	of sewage effluents)	tion

PROVISIONAL PLAN C

Baileyville town					
--Woodland	Sewage (municipal)	I	IV	Primary	III <u>2/</u>
--Pulp and paper mill	Sulfite and groundwood pulp, paper	I	IV	Coagulation, sedimen- tation or flotation for paper & ground- wood wastes; evapora- tion of strong waste sulfite liquor	III <u>2/</u>
Calais city	Sewage (municipal)	IV	IV	Primary	III <u>2/</u>
Robbinston town	Sewage (private sewers)	III	III	Subsurface disposal	II

1/ Improved to next highest condition a few miles downstream after tidal dilution and self-purification.

2/ Improved to next highest condition within a mile below outlet after dilution and self-purification.

APPROXIMATE WATER QUALITY IMPROVEMENT

30. Existing water conditions. - Under existing conditions, pollution of the St. Croix River Basin has been confined to the main stem from Woodland to Passamaquoddy Bay. From Woodland to a point about five miles below Calais, a reach of about 16 miles, the river is seriously polluted and during critical periods in a condition equivalent to a water quality generally acceptable only for

transportation of sewage and wastes without nuisance, navigation, power development and certain other industrial uses. For the next nine miles to Passamaquoddy Bay, after some self-purification and with the large dilution available, the water is in a condition generally satisfactory for game fishing, recreational boating and such other uses that do not require a high quality or are not limited by the salinity of this tidal section.

31. Water conditions under Provisional Plan A. - If the treatment shown for Provisional Plan A were in operation, the resulting water conditions would probably be as follows: From Woodland to an indeterminate point about seven miles below Calais, a distance of some 18 watercourse miles, the water conditions would be improved so as to be equivalent to a quality generally acceptable for recreational boating, irrigation of crops consumed after cooking, habitat for wildlife and common food and game fishes indigenous to the region and such other uses as do not require a high water quality. For the next seven miles, the tidal section of the main stem to Passamaquoddy Bay would be of a uniformly good quality acceptable for all water uses not limited by salinity.

32. Water conditions under Provisional Plan B. - Under the treatment measures shown for this provision plan, there would be an almost complete recovery of the main stem for all purposes. Except for short stretches of about one mile each below pollution discharges in Woodland and Calais, the main stem would be improved to a condition equivalent to a water quality generally acceptable for all purposes except public water supply unless filtered and disinfected and those purposes limited by salinity where this is

a factor. For short distances of perhaps a mile or less below Woodland and Calais, before complete mixing and dilution of treated wastes were accomplished, the water quality would not be suitable for highest uses but would be acceptable for such purposes as recreational boating, irrigation of crops consumed after cooking and habitat for wildlife and common food and game fishes indigenous to the area. This high recovery of water quality would be due in large part to the elimination of waste sulfite liquors by evaporation.

33. Water conditions under Provisional Plan C. - The treatment measures shown for Provisional Plan C are estimated to result in approximately the same improved water conditions as would result under Provisional Plan B above. With the dilution that is available at Woodland and Calais, it is estimated that primary treatment and chlorination of the municipal wastes from these two population centers would result in the same improvement in water conditions with respect to suitability for use, as would result from secondary sewage treatment.

34. Table 12 summarizes the approximate water conditions that should exist under Provisional Plans A, B and C. Water conditions are shown in miles for each condition approximately equivalent to the classes shown under Table 10.

Table 12 - Approximate effects of provisional plans on water conditions*,
St. Croix River Basin

Receiving watercourse	Approximate present water condition					Approximate water condition under provisional plans					Net water quality improvement			
	in miles					in miles					in miles			
	I	II	III	IV	V	I	II	III	IV	V	I	II	III	IV
<u>PROVISIONAL PLAN A</u>														
St. Croix River (main stem) <u>1/</u>	43	0	9	16	0	43	7	18	0	0	-	7	16	-
<u>PROVISIONAL PLAN B</u>														
St. Croix River (main stem) <u>1/</u>	43	0	9	16	0	43	23	2	0	0	-	23	2	-
<u>PROVISIONAL PLAN C</u>														
St. Croix River (main stem) <u>1/</u>	43	0	9	16	0	43	23	2	0	0	-	23	2	-

*All tributaries to the main stem, including the Chipneticook and Grand Lakes systems, are reported to be of a uniformly high quality, suitable for any water use.

1/ From Chipneticook Lakes outlet at Vanceboro to Passamaquoddy Bay.

35. Water condition improvement--Provisional Plan A. - From

Table 12 it is indicated that all but two miles of the presently affected 25 miles of main stem would be improved for higher uses under Provisional Plan A, 16 miles being returned to a good quality generally suitable for recreational boating, irrigation of crops consumed after cooking, habitat for wildlife and common food and game fishes indigenous to the area and seven miles to a high quality suitable for all uses not limited by salinity.

36. Water condition improvement--Provisional Plans B and C. -

Under Provisional Plans B and C all of the presently affected stretch of the St. Croix River would be recovered for higher uses, all but two miles for every water use excepting public water supply unless filtered and disinfected.

37. The tables and maps summarize and graphically depict Provisional Plans A, B and C and the effect of providing the treatment shown on receiving water qualities. Table 11 shows the approximate present water conditions, the treatment considered for each source of pollution and the approximate water condition that would result from the treatment under existing conditions of pollution. Table 10 is a reproduction of the "Tentative Plan for Classification of Waters" of the New England Interstate Water Pollution Control Commission and shows the suitability of the classes of water quality for use which approximates the water conditions given Condition I corresponding to Class A, Condition II to Class B, etc. Plates 7 and 8 are maps showing the approximate water conditions that would result under each provisional plan.

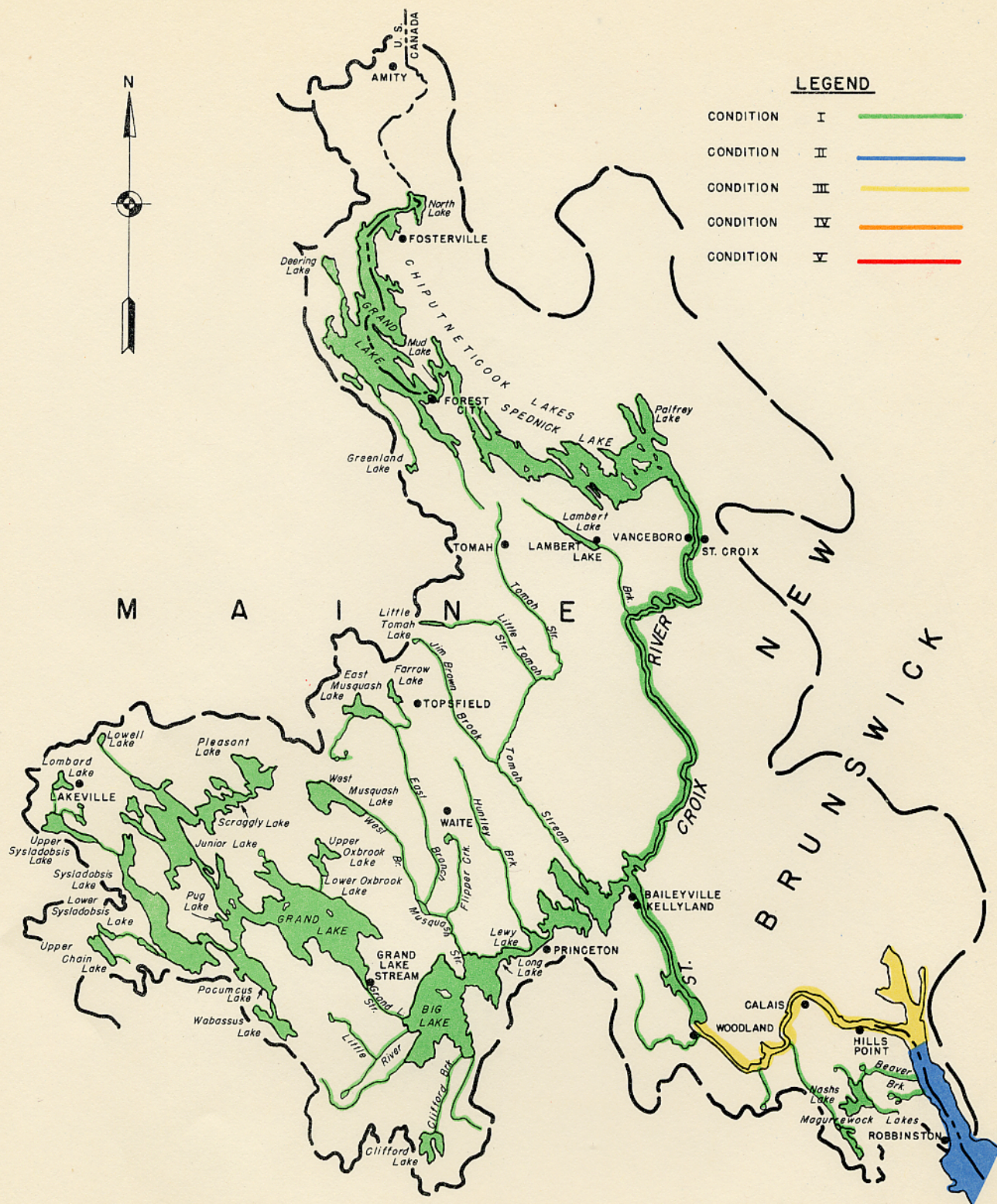
ESTIMATED COSTS FOR TREATMENT FACILITIES

38. The cost estimates for municipal sewage treatment works construction that follow include costs for intercepting sewers but do not include costs for sewerage systems or extensions there-to since such costs are not generally considered a part of sewage treatment. For industrial waste treatment or disposal

construction, no costs have been included for in-plant or yard changes that may be required in connection with treatment. Such costs could only be determined after detailed in-plant investigations at the pulp and paper mills.

39. Sewage treatment costs will vary with each project and final costs will largely be determined by method of financing, design and construction materials and equipment specified. The cost for treatment of pulp and paper mill wastes will also vary and will be determined in large measure by in-plant changes made, choice of treatment methods, plant design and construction materials and equipment specified. The cost estimates that follow, however, reasonably reflect the range of costs for the treatment methods shown in the provisional plans.

40. Estimated construction costs--Provisional Plan A. - The total construction cost for the sewage and industrial waste treatment facilities shown under this provisional plan has been estimated to be \$669,000 based on 1949 construction cost levels. Of this total, the cost of the two municipal primary sewage treatment plants and interceptors has been estimated to be \$310,000; the cost of subsurface disposal systems to serve 100 persons discharging sewage from private outlets in Robbinston, \$9,000; and the cost of industrial waste treatment at the pulp and paper mill, \$350,000.



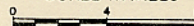
NOTE
 Not a precise evaluation
 approximated from data available.

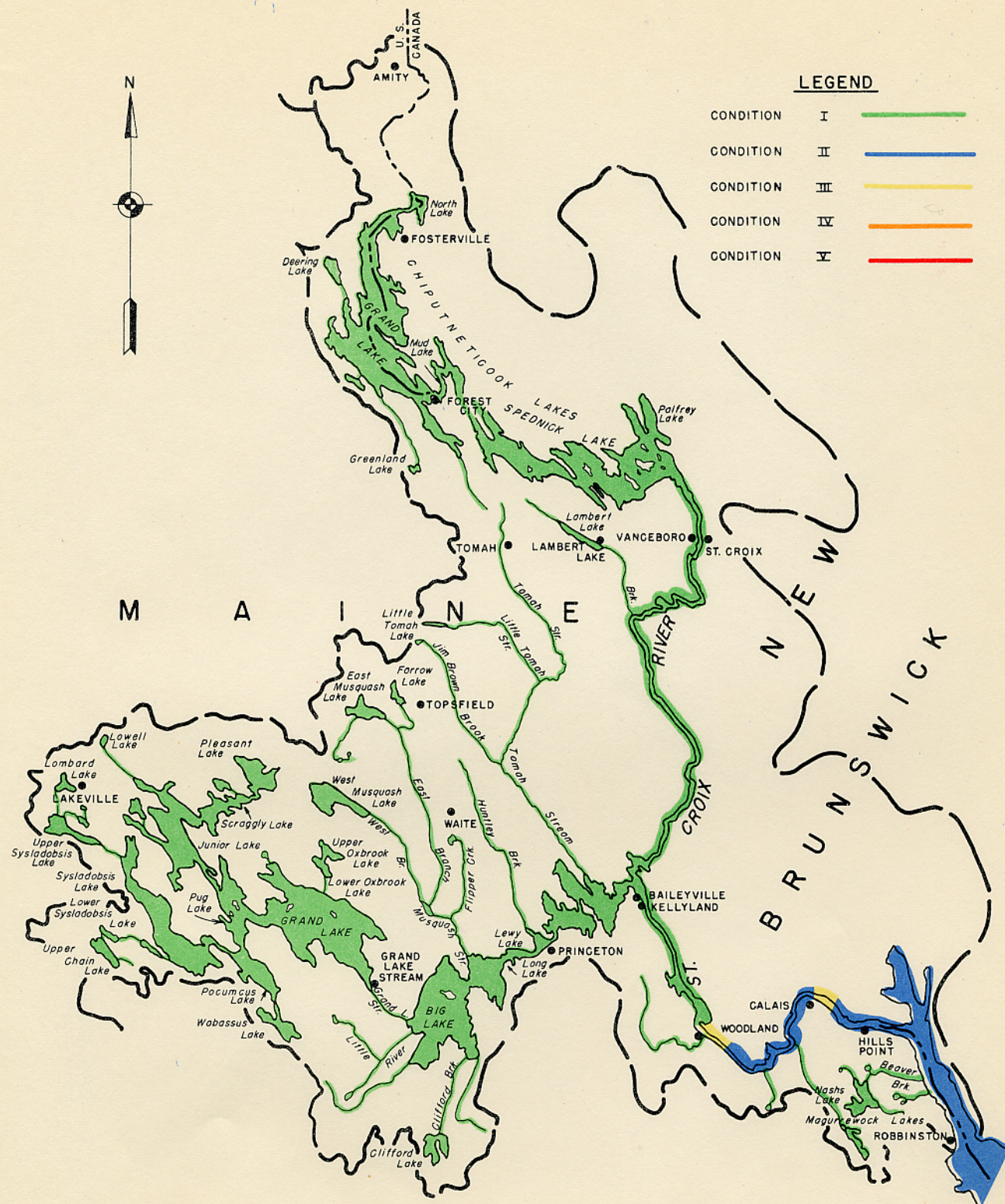
**ST. CROIX RIVER BASIN
 WATER CONDITIONS RESULTING FROM
 PROVISIONAL POLLUTION CONTROL PLAN A**

NEW ENGLAND NEW YORK INTER-AGENCY COMMITTEE

DECEMBER 1952

SCALE IN MILES



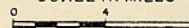


NOTE
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 approximated from data available.

**ST. CROIX RIVER BASIN
 WATER CONDITIONS RESULTING FROM
 PROVISIONAL POLLUTION CONTROL PLAN B & C**

NEW ENGLAND NEW YORK INTER-AGENCY COMMITTEE

DECEMBER 1952
 SCALE IN MILES



41. Annual charges for municipal sewage treatment--Provisional Plan A. - Based on the estimated construction cost, an amortization period of 30 years and an interest rate of 2-1/2 percent, the total capital cost for municipal sewage treatment would be \$140,000 and the annual capital charge would be \$14,800 for 30 years. Operation and maintenance costs over this period are estimated to average \$1.70 per capita served per year for an estimated 6,500 persons or an annual total of about \$11,200. The total annual charge for construction, operation and maintenance of municipal sewage treatment works would then be approximately \$26,000 for 30 years.

42. Annual charges for private sewage treatment--Provisional Plan A. - The estimated construction cost of \$9,000 for private subsurface disposal systems amortized over a period of ten years at four percent would represent a total capital charge of \$11,100 or an annual capital charge of about \$1,100 for ten years. At an average of four persons served per disposal unit and an annual maintenance cost of \$10 per unit per year, the total annual maintenance cost would be \$250 for ten years. The total annual charge for construction and maintenance of subsurface disposal systems to serve private outlets in Robbinston would be an estimated \$1,350 for ten years.

43. Annual charges for industrial waste treatment--Provisional Plan A. - The estimated cost of constructing the treatment facilities to serve the pulp and paper mill in Baileyville was \$350,000. Based on this estimate and an amortization period of ten years at four

percent the total capital charge would be \$431,000 and the annual capital charge would be about \$43,000 for ten years. Operating and maintenance costs over this period are estimated to average about 50 cents per ton of paper production which, at capacity, would be about \$35,000 per year on the basis of a 250-day work year. The total annual charge for construction, operation and maintenance of the industrial waste treatment facilities shown for this plan would then be \$78,000 for ten years.

44. Estimated construction costs--Provisional Plan B. - The total construction cost for the sewage and industrial waste treatment facilities outlined under this plan has been estimated to be \$1,783,000. Of this amount \$524,000 is estimated construction cost of two municipal secondary sewage treatment plants, including intercepting sewers; \$9,000 for subsurface disposal of sewage from private outlets; and \$1,250,000 for industrial waste treatment facilities.

45. Annual charges for municipal sewage treatment--Provisional Plan B. - The estimated construction cost for municipal sewage treatment works amortized for 30 years at 2-1/2 percent would represent a total capital cost for construction of \$751,000 or an annual capital charge of about \$25,000 for 30 years. The annual operating and maintenance costs are estimated to average \$18,000. The total annual charge for construction, operation and maintenance of secondary sewage treatment works under Provisional Plan B is estimated to be \$43,000 for 30 years.

46. Annual charges for private sewage treatment--Provisional Plan B. - The annual charge for construction and maintenance of subsurface sewage disposal systems would be the same as computed under Provisional Plan A which was estimated to be \$1,350 for ten years.

47. Annual charges for industrial waste treatment--Provisional Plan B. - Industrial waste treatment construction for the pulp and paper mill under Provisional Plan B was estimated to be \$1,250,000. These figures amortized for ten years at four percent would represent a total capital charge for construction of \$1,541,000 or an annual charge of about \$154,000 for ten years. Operation and maintenance charges would be approximately one dollar per ton of product which at capacity would be about \$68,000 per year. The total annual charge for construction, operation and maintenance of treatment facilities by the pulp and paper mill would therefore be an estimated \$222,000 for ten years.

48. Annual charges for municipal sewage treatment--Provisional Plan C. - The plan for municipal sewage treatment is the same as Provisional Plan A. The annual charge for construction, operation and maintenance of the two municipal primary sewage treatment plants was computed to be \$26,000 for 30 years, including the estimated costs for intercepting sewers.

49. Annual charges for private sewage treatment--Provisional Plan C. - The plan for treatment of the domestic sewage from private sewers in Robbinston is the same for all three provisional

plans and the annual charge for construction and maintenance of subsurface disposal systems was estimated to be \$1,350 for ten years.

50. Annual charges for industrial waste treatment--Provisional Plan C. - Industrial waste treatment would be the same as shown for Provisional Plan B and the annual charge for construction, operation and maintenance was computed to be \$222,000 for ten years.

51. Table 13 is a summary of the estimated construction costs and annual charges for sewage and industrial waste treatment in the St. Croix River Basin under Provisional Plans A, B and C.

BENEFITS RESULTING FROM WATER QUALITY IMPROVEMENT

52. Since the Maine Water Improvement Commission carries out its functions in water pollution control on the classification principle, the benefits that will eventually accrue from pollution control in the St. Croix River Basin are dependent upon the best water uses and classifications adopted by the State Legislature. Since classifications have not been adopted for the main stem, the only stream transporting significant pollution in the basin, it is not possible in this report to assign the eventual benefits from pollution control. However, as a guide to judging the costs and benefits from pollution control in the basin, three provisional plans for sewage and industrial waste treatment or disposal have been presented and the benefits which may result under these plans are discussed in succeeding paragraphs.

Table 13 - Summary of estimated construction costs and annual charges
for treatment and disposal facilities - Provisional Plans A, B and C,
St. Croix River Basin

Type of pollution :	Estimated construction cost :	Estimated annual capital charge 1/ :	Estimated annual maintenance charge :	Total 1/ estimated annual charge
<u>PROVISIONAL PLAN A</u>				
Municipal sewage	\$ 310,000	\$ 14,800	\$ 11,200	\$ 26,000
Private sewage	9,000	1,100	250	1,350
Industrial wastes	350,000	43,000	35,000	78,000
TOTALS 2/	\$ 699,000	\$ 59,000	\$ 46,000	\$ 105,000
<u>PROVISIONAL PLAN B</u>				
Municipal sewage	\$ 524,000	\$ 25,000	\$ 18,000	\$ 43,000
Private sewage	9,000	1,100	250	1,350
Industrial wastes	1,250,000	154,000	68,000	222,000
TOTALS 2/	\$1,783,000	\$180,000	\$ 86,000	\$ 266,000
<u>PROVISIONAL PLAN C</u>				
Municipal sewage	\$ 310,000	\$ 14,800	\$ 11,200	\$ 26,000
Private sewage	9,000	1,100	250	1,350
Industrial wastes	1,250,000	154,000	68,000	222,000
TOTALS 2/	\$1,569,000	\$170,000	\$ 79,000	\$ 249,000

1/ Based on amortization periods of 30 and 10 years and interest rates of 2-1/2 and 4 percent respectively for public and private construction.

2/ Totals rounded to nearest \$1,000.

3/ Totals apply only during 10 year amortization of private construction.

53. Benefits resulting from pollution control are real but may be both tangible and intangible. A tangible benefit would be represented by a direct savings in costs for water treatment for public or industrial water supply as a result of pollution control. Another example of a tangible benefit would be recovery of valuable by-products in the process of reducing pollution. Intangible benefits are those which do not readily lend themselves to computation in monetary terms. Protection of the public health, and enhanced aesthetic and scenic values through pollution control are examples of intangible benefits. For the most part benefits assigned to pollution control are intangible, largely through the absence of suitable criteria for monetary evaluations. There are occasions, however, where suitable data are available when tangible benefits from pollution control can be computed on a monetary basis, although such data are not available for the St. Croix River Basin.

54. Benefits that may accrue from water quality improvement through pollution control depend upon the uses the improved water resources will serve. There are also potential benefits through the conservation of water resources for future use. In the St. Croix River Basin, the water resources serve as public water supplies, industrial water supplies, agricultural water supplies, for all types of recreation, as a habitat for fish and wildlife, commercial fishing, propagation of shellfish, for power development and for transportation of sewage and industrial wastes. Save the last two which do not require a good water quality, these water

uses are the ones potentially to be benefited by pollution control.

55. The St. Croix River Basin is sparsely settled for the most part and not so well-developed economically as other river basins in the region. Pollution of the water resources has been confined to the main stem of the river from the village of Woodland to Passamaquoddy Bay. Conflicts between pollution and water resource use have been limited for the most part.

56. The following benefits appear to be attainable from pollution control in the St. Croix River Basin under present conditions of pollution and economic development. In the absence of suitable criteria, no monetary evaluations are made and although presented as intangible, these benefits may prove to be real and desirable of attainment.

a. There could be a significant benefit to the public health by reducing the chances for waterborne diseases through treatment or elimination of sources of sewage pollution. Sewage polluted waters are always a potential health menace.

b. The construction of municipal sewage treatment works may make the communities served more attractive to new industries requiring this municipal utility and may stimulate greater residential and industrial development, thereby significantly benefiting local economies.

c. The control of pollution from Woodland to Passamaquoddy Bay may contribute substantially to the attractiveness of the area should greater development be undertaken by the recreation industry.

d. The general welfare of the residents could be enhanced by the conservation of an important natural resource for its best uses and by a greater opportunity to benefit therefrom. Further, a clean stream in the developed portion of the basin could enhance the general reputation of the area in the eyes of visitors and vacationists.

57. There is a direct interrelation between water resource development and benefits from pollution control. The more extensive and varied water use becomes the more benefits can be obtained from pollution control to maintain the necessary water qualities for the purposes served.

58. Should an integrated natural resource development program for the basin be undertaken, it could result in a significant increase in industrial, agricultural and recreation development which would be accompanied by an increase in population. These developments would appreciably enhance the value of the water resources for public water supply, agricultural water supply, industrial water supply and recreation. Land abutting on or served by water resources suitable for industrial, residential and recreational use would also be increased in value. Pollution control measures to maintain acceptable water qualities under these circumstances would produce benefits in proportion to the magnitude of the economic development.

59. The plan for developing the land and water resources of the St. Croix River Basin will indicate in large measure the pollution control measures that would be needed to conserve the water resources for best use. The adoption of best water use would, in turn, indicate the benefits that would result from pollution control.

60. Power conservation storage and flood control. - Investigations were made of 23 undeveloped power and storage sites in the St. Croix River Basin. None of the sites studied was found to be economically feasible for development at this time.

61. Other reservoir and resource development projects. - No other reservoir or resource development project was proposed for evaluation of benefits or losses to pollution control.

Table 11 - Basic data on sources* of municipal and industrial pollution
St. Croix River Basin

Source of pollution and receiving watercourse	Number sewered or employees	Type of wastes produced	P.E. 2/ untreated wastes	Treatment provided	Adequacy of treatment	P.E. 2/ to water- course
<u>St. Croix River</u> (main stem)						
Baileyville town						
--Woodland village	1,370	Domestic	1,370	None		1,370
--Pulp and paper mill	480	Groundwood and sulfite pulp, paper	210,000	None		210,000
Calais city	4,590	Domestic	4,590	None		4,590
Robbinston town	100	Domestic	100	None		100

1/ Domestic indicates no industrial wastes intercepted.

2/ P.E. - population equivalent in number of persons based on biochemical oxygen demand.

* Industries, municipalities and other population centers discharging wastes directly to watercourse.

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SECTION VI - FLOOD CONTROL AND DRAINAGE

1. Information on high flows in the St. Croix River Basin is very meager. Normal spring freshets cause only inconsequential damages.

HISTORY AND ANALYSIS OF FLOODS

2. Flood history. - Major floods on the St. Croix River occurred in September 1909 when a maximum daily flow of 20,300 cubic feet per second was experienced at Woodland and in May 1923 when a peak flow of 23,300 cubic feet per second was recorded at the Baileyville gage below the Grand Falls Dam. The peak flow at the Baileyville gage in March 1936, when serious flooding was experienced on many New England rivers, amounted to 16,900 cubic feet per second.

3. Analysis of floods. - The floods of 1923 and 1936 were caused by heavy rains falling on a snow-covered watershed. These floods were not particularly damaging. The 1,320 square miles of drainage area above the Grand Falls Dam, about 90 percent of the basin area above Calais, contains extensive areas of lakes, ponds, and swamps which act as retarding basins for the run-off in the event of heavy rains. The comparatively flat topography of the region also tends to prevent rapid run-off. Floods cannot be considered as presenting an important problem in the basin.

DAMAGES

4. Headwater flood damage. - Headwater flood damages were determined for agricultural crops, for other agricultural resources

and for urban, residential and industrial facilities. Estimates were made of the losses that would occur at flood stages above and below a record flood. In determining agricultural crop losses by stage, the flooded area for each crop was first related to flood stages. Per acre crop values, modified to reflect monthly variations in crop values and the percentage chance of flood occurrence by months, were then applied to the area of each crop inundated at various stages to develop stage-crop loss relationships. Stage-loss relationships for all types of damageable values were converted to damage frequency curves in accordance with the methods outlined in Part III.

5. Main river and lower tributary flood damage areas. - No records are available to indicate the extent of damage sustained in 1909. The damage caused by the 1923 flood, including the loss of a bridge and sawmill near Calais, Maine has been estimated at less than \$50,000. No estimates have been made of the flood damages in 1936. Information from the Maine Public Utilities Commission indicates that industrial plants near Milltown have been affected from time to time by floods. Estimates of annual flood damages on the main river and lower tributaries have not been made, but the amount of such damages would be small.

6. Erosion damages. - Erosion damages on cropland were determined by estimating the rate of soil loss and the average annual reduction in yield due to erosion. The average annual value of the loss over a 30-year period at four percent discount rate is

\$2,700 at 1949 price levels.

7. Sedimentation damages. - Each year some land, especially on steep slopes, or recently plowed land, suffers erosion in times of severe storms, and the eroded material may reach highways, drainage ditches and streams. The sediment produced by erosion may cause an amount of damage reflected in additional costs necessary to clean highway culverts, protect bridges and maintain navigation channels. These maintenance costs are such a small percentage of the total that accounts do not show them separately. Monetary evaluation of sedimentation damage has not been included in damage totals.

8. Total damages. - Total average annual flood and erosion damages are shown in Table 15.

Table 15 - Average annual flood and erosion damages,
Saint Croix River Basin

	<u>1949</u> <u>price level</u>	<u>Projected</u> <u>price level 1/</u>
Floodwater damage:		
Headwater areas	\$2,800	\$2,500
Main stream and tributary	Not available	Not available
Cropland erosion damage	<u>\$2,700 2/</u>	<u>\$2,400 2/</u>
Total damages	\$5,500	\$4,900

1/ Estimated future level of prices

2/ This figure represents only the net income loss from yield decline due to sheet erosion.

NEEDS

9. Basin requirements. - The average annual damages totaling \$5,500 indicate a minor need for flood protection in the headwater area and erosion control to reduce losses. The need for erosion control exists through the basin. At the public hearing of the Committee at Augusta, Maine on June 12, 1952 no requests were made for flood protection or erosion control measures in the St. Croix Basin. General requests for erosion control were made at the hearing.

PLANS OF DEVELOPMENT

10. Existing flood control improvements. - There are no existing flood control improvements in the St. Croix River Basin. During the period of flood hazard in the spring the U. S. Weather Bureau Office at Portland issues a bulletin evaluating existing flood potential in the State of Maine for distribution.

11. Consideration of flood control improvements. - A preliminary investigation of this basin has indicated that the extent of the annual damages is not sufficient to justify flood protection works.

12. Effect of land treatment program on floods. - The land treatment measures planned for the primary purpose of securing an optimum level of agricultural production in the basin would, upon installation, exercise a beneficial effect on the characteristics of the watershed. The measures include adjusting land use with land capability, adoption of improved cropland and forest land management practices, and installation of the necessary minor structures needed to make the land conversions and improved management measures

fully effective. A complete description of the land treatment is included in Chapter X, Maine Coastal Area.

13. The beneficial effect of the proposed land treatment program in reducing flood flows in the St. Croix River Basin is dependent upon three principal variables:

a. Frequency and type of flood producing storms.

b. Acceptance of the program by landowners and the progress which they make to put the various elements of the program into operation throughout the area.

c. Continuation of the practices throughout the years after they have once been put into operation.

14. The full benefits of the program in reducing flood flows would not be felt immediately upon adoption of the program. Instead the benefits would increase with time. From some of the work contemplated in the program, such as small structures, flood flow reduction would begin to accrue as soon as they were constructed; other operations would produce their full benefits within two or three years; from some the full benefit would not be felt for four or five decades. The program would have its maximum effectiveness on floods of one-year or two-year frequency. For the larger and less frequent floods, effectiveness would be less. Hydrologic evaluation of the program indicates that reductions of flood discharges would result from the recommended measures after they were installed by substantially all of the owners of agricultural and forest land.

These measures would be provided by individual farmers for agricultural purposes and no cost would be charged to flood control.

15. The land treatment would effectively control cropland erosion by the development of plant roots capable of holding the soil on the land. With the prevention of erosion on cropland, benefits from reduced sedimentation would also be obtained.

BENEFITS

16. Since there is no general basin plan of flood control, flood control benefits are limited to those benefits incidental to the land treatment measures and to the reduction of flood damages by a combination of alert forecasting and local planning for mobilization of flood fighting forces. The annual flood control benefits which would accrue from the land treatment measures would amount to \$300 in the headwaters, and would be negligible on the main stem. Land treatment measures would reduce erosion loss by \$2,700 annually at 1949 price levels. Benefits from land treatment measures, by reduction of sedimentation on highways and in channels, have not been evaluated. Table 16 gives a summary of benefits.

Table 16 - Summary of ultimate flood reduction and erosion control benefits incidental to land treatment,
St. Croix River Basin

	<u>1949 price level</u>	<u>Annual benefits</u>	<u>Projected price level</u>
Reduction of flood water damage	\$ 300		\$ 300
Reduction of erosion on cropland	2,700		2,400
Total benefits	\$ 3,000		\$ 2,700

SUMMARY AND CONCLUSIONS

17. Summary. - Floods have been relatively infrequent in the St. Croix River Basin. Works for the sole purpose of reducing flood damages are not economically justified at this time. Small incidental flood control benefits would be provided by the land treatment measures of the Coordinated Basin Plan. An economical reduction of flood damages may be obtained by providing a flood forecasting and warning service coupled with local plans for protective measures to be taken on the basis of such forecasts and warnings. In this basin where there is a very short time interval between onset of rainfall and ensuing flood, it may be possible to train a local representative in procedures for issuing warnings based on a special river and rainfall network reporting to him. Appreciable erosion control and sedimentation benefits would be provided by the land treatment measures of the Coordinated Basin Plan.

DRAINAGE

18. There are no drainage problems of major importance in the St. Croix River Basin.

SECTION VII - POWER DEVELOPMENT

AVAILABLE POWER

1. Existing developments. - There are three hydroelectric power developments in the basin with an aggregate installed capacity of over 11,150 kilowatts exclusive of mechanical power. They utilize a total gross head of 122 feet on the main river. These plants, all privately-owned industrial developments, include a hydroelectric plant at Grand Falls near Kellyland, Maine; a pulp and paper mill at Woodland, Maine; and a cotton mill at Milltown, New Brunswick. The hydroelectric plant at Grand Falls, with a developed gross head of 52 feet, has an installed capacity of 9,652 kilowatts and furnishes power by transmission lines to the pulp and paper mill at Woodland. The plant at Woodland, operating under a gross head of 48 feet, has installed electric generating facilities for 1,500 kilowatts in addition to mechanical power. Information available on the power development at the cotton mill in Milltown, New Brunswick lists this plant as a 3,940 horsepower installation with a gross head of 22 feet. ^{1/} Power from this plant, in addition to meeting the requirements of the mill, is supplied to the New Brunswick Electric Power Commission. Pertinent data on existing hydroelectric developments on the river are summarized in Table 17.

^{1/} Ninth Biennial Report of the Maine Public Utilities Commission (1939-1940).

Table 17 - Existing hydroelectric plants,
St. Croix River Basin

Owner	Plant name or location	Stream	Drainage area (sq.mi.)	Gross head (feet)	Installed capacity (kilowatts)	Average annual generation (kilowatt-hours)	Use*
St. Croix Paper Co.	Grand Falls Plant, Kellyland, Baileyville, Me.	St. Croix	1,320	52	9,652	48,000,000	I
" "	Woodland Plant, Woodland, Baileyville, Me.	" "	1,350	48	1,500 (1)	7,500,000	I
Textile Sales Limited(3)	Milltown, New Brunswick	" "	1,469	22 ₊	- (2)	-	I

(1) Excluding approximately 11,200 horsepower mechanical power.

(2) 3,940 horsepower.

(3) Owned by Canadian Cottons, Ltd., prior to January 1, 1953.

* I - Industrial.

2. The International St. Croix River Board of Control. -

Operation of the dams at Grand Falls (near Kellyland) and Milltown are subject to control by the International St. Croix River Board of Control. This Board was organized pursuant to conditions set forth in orders of the International Joint Commission, dated November 9, 1915, approving the maintenance and operation of the dam built at Grand Falls. By the orders of November 9, 1915, as amended October 6, 1931, the Board is charged with the duty of formulating and administering rules under which the power plant and accessories at Grand Falls are to be operated to prevent as nearly as possible a level of water at the dam higher than 203.5 feet, mean sea level datum, and to secure to the users of water below Grand Falls the flow of water to which they are entitled. The responsibilities of the Board were extended in 1923 to include the supervision of the operation of all fishways now or hereafter constructed or repaired on that portion of the St. Croix River that forms the international boundary.

3. On October 2, 1934, the International Joint Commission issued an order approving the reconstruction of the dam owned by Canadian Cottons, Limited, at Milltown, Maine, and Milltown, New Brunswick. This order contained the following conditions;

- a. That the reconstructed dam be so operated as to insure that the forebay levels rise to no higher elevation than that which has heretofore obtained in the operation of the dam now being replaced.

- b. That during times of flood the sluiceways of the dam shall be sufficiently open to insure passage of the river flow.
- c. That the operation of the dam, insofar as is necessary to insure the observance of the provisions of this order, be under the supervision of the International St. Croix River Board of Control.

On January 1, 1953, ownership of the plant of Canadian Cottons, Limited, was transferred to Textile Sales, Limited.

4. Available power. - The public demand for electric power and energy in the Maine portion of the basin is met by a number of small companies. These include the Denny's River Electric Cooperative Inc., St. Croix Electric Company, Kingman Electric Company, and Kingman Cooperative.

HYDROELECTRIC POWER INVENTORY

5. An investigation of the power and storage potentialities of 23 sites in the basin, shown on Index to Sites, Plate 9, revealed none that are economically feasible of development at this time. Preliminary investigations resulted in the elimination of 11 sites from further consideration early in the course of the study. The detailed studies which led to the elimination of the remaining 12 sites are summarized below.

6. Detailed investigation of rejected sites. - Of 12 sites studied in detail, 11 are on the main St. Croix River and are, therefore, international in character. The detailed studies included consideration of two distinct alternative plans of

development as summarized in Table 18. The first, designated as Plan A, consisted of five run-of-river power projects utilizing 165 feet of presently undeveloped head on the main river, including 130 feet at three sites between Vanceboro, Maine, and Grand Falls Flowage. The studies of this plan were based on present stream flow conditions with no re-regulation of existing storage. The second plan, designated as Plan B, included one power project with a gross head of 80 feet on Grand Falls Stream, and five power developments on the main river, including one with storage, utilizing 253 feet of fall. This fall of 253 feet includes 24 feet of developed head at existing plants. Two modifications of Plan B were also considered. The first alternate provided for combining the features of two projects at Milltown and Calais in a single development. The second considered the possibilities of an alternate site near Calais operating on a gross head of 86 feet in lieu of three developments with a total head of 98 feet. Pertinent information on the 12 sites (13 rejected projects) considered in detail is contained in Table 18.

7. The five projects in Plan A (see Table 18) proved to be unfavorable on the basis of costs of construction alone. Therefore, no estimates were made of the costs for real estate and relocations in connection with these five projects. In the case of considered developments at Milltown, site nos. SC-14b and SC-15, an important part of the first cost is in lands and

Table 18 - Hydroelectric projects investigated in detail,
St. Croix River Basin

Project and site number (1)	River mileage (2)	Drainage area (sq.mi.)	Elevation		Gross head (ft.)	Installed capacity (kilowatts)	Average annual output (kilowatt-hours)	Estimated first cost \$
			Head- water (ft., m.s.l.)	Tail water				
PLAN A								
Halls Rips (SC-5)	60	465	370	320	50	1,600	12,502,000	3,603,000 (3)
Steep Bank (SC-7)	52	502	300	255	45	2,200	13,285,000	3,366,000 (3)
Canoose Rips (SC-8)	45	523	255	220	35	2,000	14,058,000	3,860,000 (3)
Bailey Rips (SC-13)	22.5	1,378	95	80	15	1,000	14,213,000	4,305,000 (3)
Milltown Upper (SC-14a)	15.8	1,469	63	43	20	1,400	21,091,000	3,288,000 (3)
PLAN B								
Little Falls (SC-6)	58	473	370	295	75	10,000	26,854,000	10,493,000
Canoose (SC-8a)	42.5	600	290	210	80	15,000	40,865,000	17,250,000
Big Lake to Grand Lake (SC-11)	53 (4)	224	298	218	80	7,500	16,492,000	5,605,000
Baring (Alt.) (SC-13a)	20.7	1,389	98	74	24 (7)	5,000	22,321,000	4,602,000
Milltown (SC-15)	15.5	1,469	74	24	50) (8)	10,000	54,338,000	19,815,000
Cove (SC-16a)	14.2	1,473	24	0	24)	3,000	25,977,000	4,171,000
PLAN B, ALTERNATE 1								
Milltown (SC-15) (5)	15.5	1,469	74	0	74 (8)	13,000	77,707,000	24,944,000
PLAN B, ALTERNATE 2								
Milltown (Alt.) (6) (SC-14b)	16.6	1,469	96	10	86 (8)	17,000	80,389,000	20,211,000

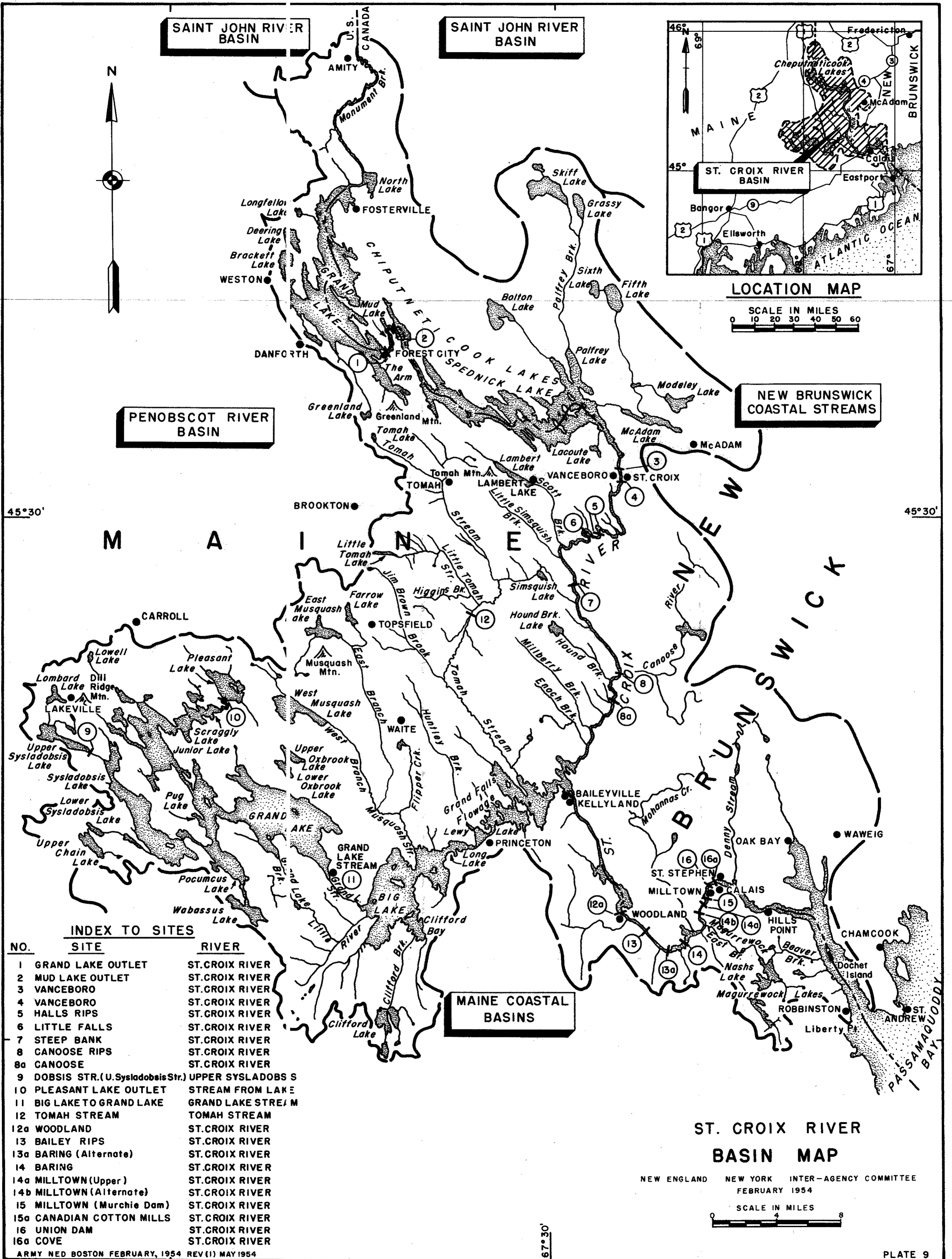
NOTE: There are no projects in this basin which are economically feasible at this time or meet the criteria for inclusion in an inventory power plan.

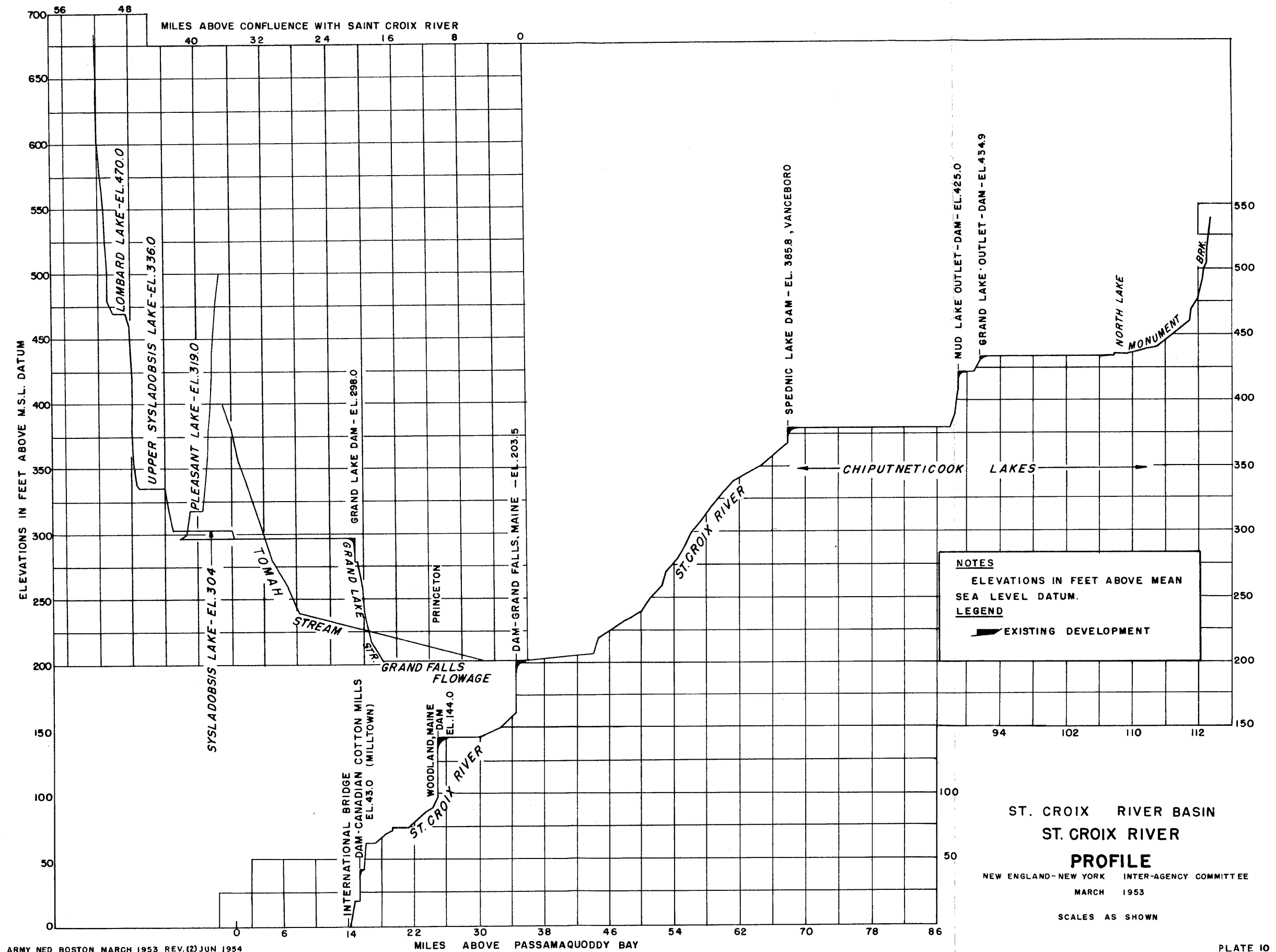
- (1) Site numbers shown on Plate 9.
 (2) Approximate. See Profile, Plate 10.
 (3) Cost is exclusive of real estate and relocation which were not determined because of high construction costs.
 (4) Mileage continued up Grand Falls Flowage and Grand Lake Stream.

- (5) Alternate for SC-15 and SC-16a in Plan B.
 (6) Alternate for SC-13a, SC-15, and SC-16a in Plan B.
 (7) Includes two feet of presently developed head at existing plant upstream.
 (8) Includes 22 feet of presently developed head at existing plant.

relocations. The construction of a project at Milltown with a headwater elevation of 74 feet mean sea level, as in Plan B and Alternate 1, would entail the construction of a new railroad bridge and the relocation of three miles of railroad and major parts of the villages of Milltown, Maine, and Milltown, New Brunswick. The construction of a project with a headwater elevation of 96 feet, as in Alternate 2, would also necessitate the erection of a new railroad bridge and, in addition, the relocation of 8.3 miles of railroad, six miles of highways and utilities, and the entire villages of Baring, Maine, and Upper Mills, New Brunswick. The extensive amount of required relocation work precludes the construction of a high dam at Milltown under present conditions.

8. The annual costs of each of the 13 rejected hydroelectric developments, based on private financing, were found to be far in excess of the benefits to be obtained. The benefits were taken as equal to the annual value of equivalent power from privately financed steam plants in the vicinity of the hydroelectric sites, assuming minor transmission liability. These are the maximum values that could be assigned to the power from new hydroelectric projects in the basin and resulted in benefit-cost ratios for the projects of less than 0.6 to 1. Since no additional upstream storage was found to be economically justified, the re-development of existing plants on the river was not considered.





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SECTION VIII - NAVIGATION

1. Commercial navigation in the St. Croix River Basin is limited to the 14-mile tidal portion of the main river and estuary between Calais and Passamaquoddy Bay. Upstream from Calais the St. Croix and its tributary waters are used for recreational boating and for the transportation of logs.

2. Authorized project. - The existing navigation project in the St. Croix River was authorized by the River and Harbor Acts of March 3, 1881, and June 25, 1910. The Act of 1881 provided for the repair of fender piers previously constructed by the Lighthouse Establishment at the Ledges about 4.5 miles below Calais. The Act of 1910 provides for a channel 12 feet deep and 200 feet wide from the 12-foot depth opposite Hills Point to the lower steamboat wharf at Calais, a distance of about two miles; then nine feet deep and 150 feet wide for a distance of about 1.4 miles to the public landing at St. Stephen, New Brunswick; and then nine feet deep and 100 feet wide for about 0.3 mile to the upper steamboat wharf at Calais. All project depths refer to the plane of mean low water. Owing to the international character of the project, the Act of 1910 required that the Secretary of State conduct negotiations with the Government of Great Britain with a view to cooperation in the project. As a result of these negotiations, the Canadian Government agreed to pay 10 percent of the cost of

the work upon its completion, and during the fiscal year ending June 30, 1917, paid to the United States the sum of \$19,891.65. The project was also authorized subject to the condition that assurances be furnished that the practice of dumping sawmill waste into the river be stopped. This condition has been fulfilled.

3. Status of project. - The first work on the St. Croix River was accomplished by the Lighthouse Establishment in 1856, prior to the adoption of the existing project. The work consisted of the construction of three crib piers about 4.5 miles below Calais to keep vessels from drifting onto a ledge on the right bank. The authorized channel project was completed in 1916. No work has been done on the project since that time with the exception of a condition survey completed in August 1949. The controlling depths in 1949 were five feet from Hills Point to a point about 150 feet below the public landing at St. Stephen, then six feet to the upper steamboat wharf except for a shoal area with a depth of 2.4 feet on the northerly side of the channel in front of the public landing. The total cost to the United States under the authorized project has been \$186,000 of which about \$179,550 was for new work and \$6,450 for maintenance. Including the contribution by the Canadian Government, the total cost has been approximately \$205,892. These costs have all been incurred in connection with the channel project.

4. Commerce. - Since 1940, with the exception of the war years, annual commerce on the river has averaged about 25,000 tons, mostly petroleum products. Annual commerce on the river averaged 24,000 tons during the years 1940 and 1941; 6,500 tons during the years 1942 to 1945, inclusive; and 26,000 tons from 1946 through 1952. It attained a peak of 33,000 tons in 1947. The commerce in 1952 consisted of about 23,400 tons of fuel oils, gasoline, and other petroleum products; 1,300 tons of fresh and frozen fish; and 400 tons of other commodities. Most of the tonnage was destined for Calais. The boats using the river are principally motor vessels with drafts ranging from three to 14 feet. Of the 328 commercial vessels that entered the river in 1952, 21 had reported drafts of 12 to 14 feet.

5. Adequacy of the existing project. - A review of the navigation potentialities of the St. Croix River was made in 1930. It found that the existing project was adequate at that time for the needs of navigation below Calais, and that any extension of navigation above Calais could not be economically justified. A further review of the project in 1936 was also unfavorable to any modification of the existing project. The project as presently constituted and maintained is considered adequate for the present needs of commerce on the river below Calais. There is no present or prospective need for improvement of the river above Calais in the interest of navigation.

SECTION IX - FISH AND WILDLIFE

WILDLIFE

1. Game and fur species of wildlife in the St. Croix River Basin consist almost entirely of forest-inhabiting or aquatic animals. This watershed is outside the range of common agricultural wildlife species.

2. Forest and aquatic game animals include the white-tailed deer, black bear, moose (not legally hunted), ruffed grouse, gray squirrel, varying hare, woodcock, and waterfowl. Fur animals of importance include the beaver, mink, and muskrat. Also present are the otter, skunk, raccoon, red fox, weasel, bobcat, and probably a few marten and fisher.

3. Deer. - The single most important game animal in the basin is the deer. From the standpoint of hunting pressure and recreational income no other species offers a comparable attraction to hunters. Approximately 1,400 deer were legally killed during 1950 in that portion of the St. Croix basin which is in the State of Maine. Hunters spend an average of \$136 for each deer killed, representing an annual expenditure of nearly \$200,000 in the area. Hunting camps, catering to nonresident sportsmen, are an important enterprise in this watershed.

4. Habitat conditions for deer are fair to excellent in this basin. Certain of the more remote areas provide the smallest harvest of deer. This small kill undoubtedly reflects the

inaccessibility of large areas to hunters, but it may also suggest the limited potential of unbroken forest in sustaining large populations of deer. Dyer Township contains mostly little used lands and yet has provided sizable deer harvests in recent years. The explanation for this circumstance rests on the fact that many woods roads have been constructed and considerable cutting has taken place.

5. The black bear. - Another species of forest wildlife in the big game category is the black bear. Bears are distributed over the entire basin. In 1950 agricultural bounties were paid on approximately 58 bears killed in the basin. Undoubtedly other bears were killed for which no bounty payments were claimed. While some bears were probably shot or trapped for the \$15 bounty offered, many are killed incidentally by deer hunters. In recent years an increased interest in bear hunting has developed, particularly on the part of nonresident hunters. There is no closed season on bear and spring hunting is becoming popular.

6. Moose. - Moose are scattered in small numbers throughout the St. Croix River Basin and their numbers are reported to be about stabilized. Habitat conditions are good for moose in most sections of the basin but accidents and various depredations, including poaching, apparently preclude any appreciable increase in numbers of the moose herd. Moose have been protected for many years in the basin and it is doubtful whether any harvestable

surplus will be established in the foreseeable future. It is worthwhile to note that this species is of value to the area despite the fact that it provides no hunting recreation. Moose are very scarce in the eastern United States and the preservation of the remnant herds is of tangible importance.

7. Other forest game. - Of the upland forest game in the basin, ruffed grouse, varying hare, and woodcock are important. Gray squirrels are scarce in this section of Maine but grouse and hare hunting are second only to deer hunting in popularity. Woodcock are sought throughout the watershed and it is in this basin that the only federal refuge for the study of woodcock has been established. The Moosehorn Refuge is located near Baring in the southeastern section of the basin and includes over 22,000 acres devoted to wildlife development. Much of this development is for species other than woodcock, waterfowl being an important consideration.

8. Areas of excellent grouse, woodcock, and varying hare habitat are found in the St. Croix watershed. Favorite hunting sites are located in the vicinity of Vanceboro, Carroll, Topsfield, Waite, and Woodland. More remote areas in the basin are hunted along the margins of roads which penetrate these reaches of the basin.

9. Waterfowl. - Several good waterfowl areas are located in the basin and while no large concentration areas exist, the

waterfowl production is, in the aggregate, considerable. Much of the better habitat is located at Spednic Lake, the main stem St. Croix River, Tomah Stream, Musquash Stream, Big Lake, Grand Falls Flowage, and Magurrewock Stream. While waterfowl hunting is popular, it is doubtful if this resource is as heavily utilized as deer and upland game.

10. Furbearing animals. - The muskrat, beaver, and mink comprise the important fur bearers in the basin. All three species are widely distributed, with muskrat populations greatest in the same areas as the better waterfowl habitat.

11. Amateur and semi-professional trappers utilize the fur resources and schoolboys and part-time trappers undoubtedly account for nearly all the annual harvest. Actually the take of fur animals must comprise but a small part of the total wildlife value of the watershed. The annual catch of beaver for the entire state is about 4,500 animals, while 3,000 to 4,000 mink and about 30,000 muskrats are taken. 1/ Annual fur harvests may fluctuate sharply, but inasmuch as the St. Croix Basin includes less than four percent of the land area of Maine, it may be assumed that income from this activity is low. Certainly the values are inconsiderable as compared to the deer resource.

1/ Gashwiler, Jay S. 1948, Maine Muskrat Investigations; Bulletin of Maine Department of Inland Fisheries and Game.

FISH

12. For many years the St. Croix River Basin has provided a varied, productive fishery which has been utilized by local anglers and many nonresident sportsmen. Originally the chief attraction of the area was the cold-water fishery for landlocked salmon, brook trout, and lake trout. Historically, there existed an Atlantic salmon fishery of considerable proportions in the St. Croix River as well as alewife and shad fisheries. Most of the fishing for Atlantic salmon was of a commercial nature until 1825, when dams were built on the river. The Atlantic salmon fishery was all but extinct before the popularity for rod and reel fishing had developed.

13. Brook trout. - General patterns of fish distribution in this basin are about the same as to be found in the other northern and eastern basins in Maine. Brook trout inhabit all the brooks and streams. They are also found in most of the ponds and lakes, at least seasonally, and in greater or lesser numbers depending on the quality of the environment. Lake trout comprise an important item in the fishery only in the large, deep lakes of the area. East Grand Lake and Grand Lake provide most of the lake trout fishing in the basin.

14. Salmon. - Landlocked salmon are native to the St. Croix Basin. The so-called "Schoodic" salmon have provided excellent fishing in Grand Lake and Grand Lake Stream since the earliest

days of sport fishing. Many salmon are now taken in the Grand Lake area and this species has been distributed in other segments of the basin. East Grand Lake, in particular, offers excellent landlocked salmon fishing. Whitefish also inhabit East Grand Lake, where they have been of commercial importance. No sizable fishery exists for this species at the present time.

15. Bass. - The cold-water fishery remains very important in the St. Croix basin, but warm-water species, particularly smallmouth bass, presently comprise a significant resource. Bass are especially sought after during the summer season. The Big Lake area, Grand Falls Flowage, and Spednic Lake are the notable bass producing areas and are intensively fished by resident and non-resident anglers. Smallmouth bass are also found in the lower extremities of tributary streams such as Musquash Stream, Tomah Stream, Grand Lake Stream, and along the entire St. Croix River. Although bass fishing is confined principally to these lakes, bass have been caught during recent years in the larger trout and salmon lakes.

16. Smallmouth bass, a fish artificially introduced to this basin, provides by far the most important warm-water fishery resource. Other warm-water species, while contributing perhaps as greatly to the total harvest in numbers, are frequently taken incidentally by fishermen whose chief interests are in catching smallmouth bass.

17. Other fish. - Chain pickerel, white perch, and yellow perch inhabit the St. Croix Basin. The range of these species in the watershed generally parallels that of smallmouth bass. White perch are probably associated with the penetration of bass into salmon and trout waters to a greater degree than the yellow perch and pickerel. In fact, the white perch have undoubtedly always had a greater distribution in the basin, at least in larger numbers, than the other warm-water game fish.

18. Recreation facilities. - Utilization of the fishery resources in the St. Croix Basin by resident and nonresident fishermen provides much of the basis for the recreation business in the area. Facilities for sportsmen are concentrated in the vicinity of Grand Lake Stream, Princeton, Danforth, and Vanceboro. Sporting camps, cottages, boat liveries and guide services are available at nearly every popular fishing site in the basin.

ECONOMIC ASPECTS

19. Little data exists which would indicate monetary values which might be assigned to the fish and wildlife resources of the St. Croix Basin. Some information is available on a statewide basis, and it is presented in a summary report of the fish and wildlife resources for Subregion "A". Monetary evaluation of certain wildlife species is more readily obtainable than for other wildlife species. An estimated expenditure of \$200,000 annually by deer hunters in the basin was noted earlier in the

report. Estimates of this nature are only approximate and often fail to illustrate the actual value of a particular resource.

20. Monetary evaluations of this type, even if soundly arrived at, can only be used as an indication of the importance of fish and game resources. Perhaps the greatest values are of an aesthetic nature and are impossible to evaluate.

21. Certainly it is clear that fish and wildlife provide much of the stimulus for the recreation business of the basin. The economy of all the more remote areas in the watershed has as its base only two enterprises: (1) the harvesting of forest products and (2) the production and utilization of fish and game. These renewable resources sustain the economy of much of the basin, and the latter category provides recreation of inestimable value to residents and to nonresidents from a wide area.

NEEDS AND DEVELOPMENT OF FISH AND WILDLIFE

22. Work of a general management nature has been limited to enactment and enforcement of laws and predator control. In the future it may be profitable to expand the management features of the wildlife program of the basin. Inasmuch as farm game species are of little consequence in the area, it may be anticipated that programs would involve the management of woodlands and marsh areas. The Great Works Marsh Development in the adjoining Dennys River basin is an excellent example of a waterfowl and muskrat management area.

23. Few marsh areas exist which can be developed economically, but wildlife management of woodland areas would be possible over wide areas in the basin. This management over large acreages would necessitate the formulation of agreements between the state conservation agency and private landowners. In particular this would require negotiations with the large pulp and paper or woodland companies. This type of cooperation has been successful in New Hampshire.

24. It is not expected that any detailed rules could be drawn up to coordinate forest practices activities with the demands of wildlife. Rather, it is felt that liaison should be maintained between woods operators and conservation officials. Deer wintering sites, stream margins, marsh areas, small reservoirs, and any other areas of significance to wildlife should be preserved and developed. Any comprehensive management plan for wildlife in the larger river basins of Maine will certainly require the cooperation of the large land-holding companies.

25. Control of habitat changes. - Gross environmental changes, such as increased farming activity, land abandonment, or clear-cutting of forests is not taking place in the basin. Changes in the over-all composition of wildlife habitat come about slowly as a result of lumbering. Therefore, in order to control abuses to the habitat or to increase benefits it will be necessary to enlist the cooperation of the agents of habitat changes in this and other basins.

26. The loss of considerable numbers of deer during the winter seasons is a problem in this basin. These losses occur as a result of heavy snow cover combined with populations of deer in excess of available food supplies, and predation, especially from wildcats. Bounties are paid for wildcats killed in Maine and about 20 were taken in the St. Croix Basin during 1951. Winter losses due to inadequate food supplies are likely to be a continual problem, but the situation would be eased in part by cooperation between landowners and conservation interests as outlined above. Losses would still occur, but it would probably be possible to sustain a larger herd through the critical winter period.

27. Poaching, either through illegal night hunting or under the guise of crop protection, is a serious problem in the area. Poaching in any form is unfair to the true sportsmen and to those who derive their livelihood from the recreation business. Most objectionable, however, is the practice of wilfully hunting deer under the existing statutes which are designed to afford the farmer legitimate protection for his crops. A vigilant warden force devotes much of its time to this problem, but apprehension of violators and obtaining convictions is difficult. It is expected that illegal hunting, especially for deer, will continue. Proper and long-term education may be the only manner in which progress can be achieved in this regard.

28. Fishery resources. - In considering the needs of fishery resources, dams and reservoirs, pollution and species competition comprise the basic problems in the St. Croix River Basin.

29. The valuable fishery for alewives, shad, and Atlantic salmon is largely a thing of the past as a result of permanent dams which have been constructed in both the upper and lower basin. These obstructions to anadromous fish migrations continue.

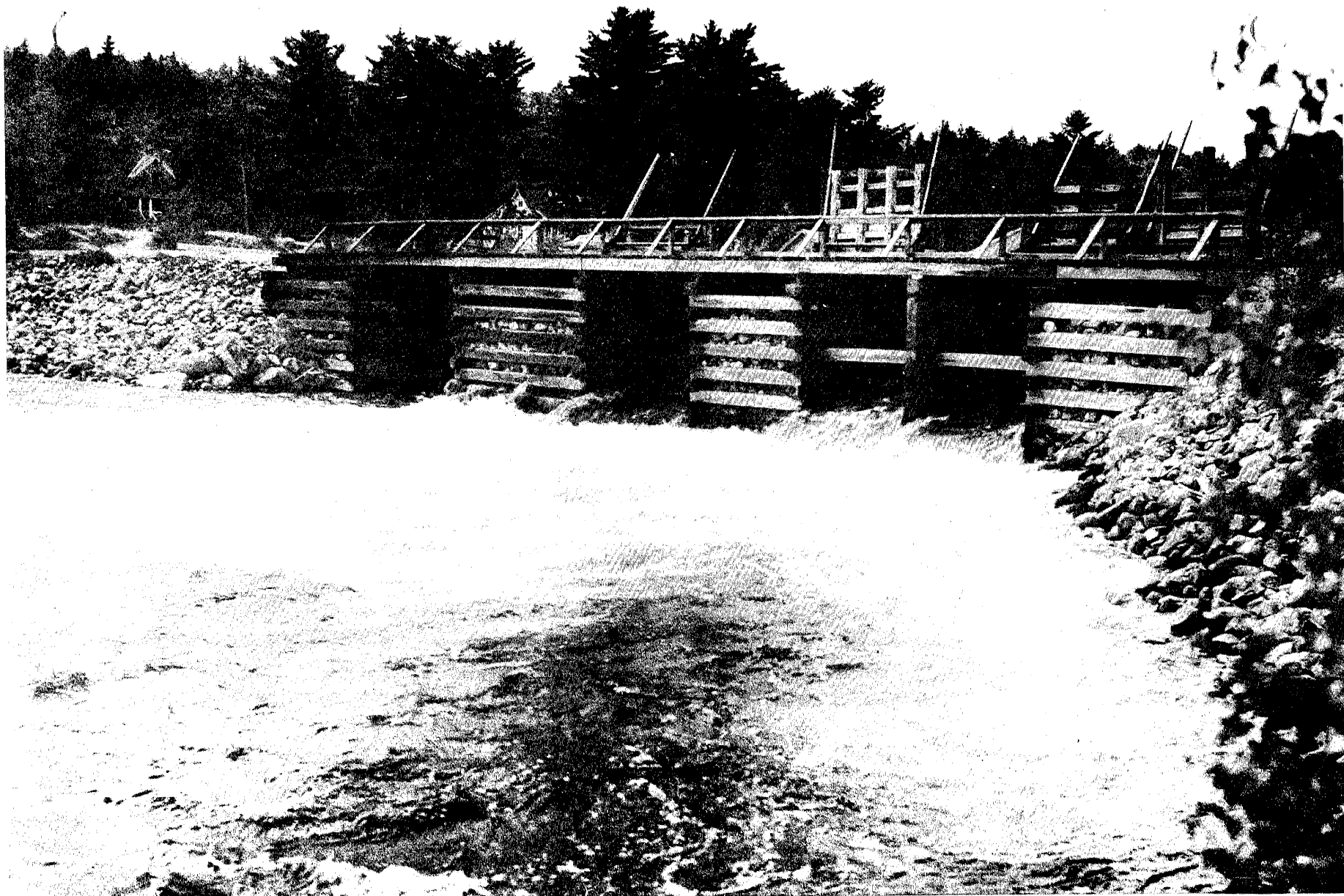
30. Effect of dams. - It is important to recognize that the presence of dams and reservoirs may have a damaging effect on interior, indigenous fish species in addition to the problem created with regard to anadromous fish. Harmful effects on numbers of fish may include one or more of the following factors: warming of water through increased surface areas, flooding of spawning streams and fishing sites, restrictions on free movement of fish into desirable habitat, poor growth of fish which are denied access to favored areas, crowding of spawning sites with increased predation, killing of fish in passage through power facilities, disruption of normal flow patterns below dams, intensification of pollution menace when flows are restricted, unattractiveness of shorelines of unstable reservoir pools, and destruction of the spawn of lake trout and other fish species when drawdowns of reservoirs follow the spawning season.

31. The construction of dams may, of course, be of benefit to fishery resources under certain circumstances. These benefits

may include the following factors: increased fish food production when impounded waters create expanses of shallow fringes, creation of desirable barriers to the encroachment of unwanted fish species, and possible stabilization of stream flows along downstream areas which would mitigate the effects of droughts and pollution.

32. Dams along the main stem of the St. Croix River have eliminated anadromous fishes from the watershed. Three dams are now located on the river at Milltown, New Brunswick and at Woodland and Kellyland, Maine. None of the dams is equipped with fishways and all are barriers to fish migration. The dam at Milltown inundates only a short reach of the river, but the Woodland Dam floods about 5.4 miles of river, and the Kellyland Dam floods one-half mile of the main stem, eight miles of the West Branch, and three miles of the East Branch. High quality bass and pickerel fishing is provided in the Grand Falls Flowage formed by the Kellyland Dam.

33. Much of the drainage area of the West Branch St. Croix River is situated upstream from the outlet at Grand Lake Stream. A dam at the outlet controls the flow from all the Schoodic Lakes area. Numerous tributaries enter these lakes, but nearly all are of small size. The flow at the outlet is of considerable magnitude, however, and it is presumed that much spawning of salmon occurred in this outlet before the dam was built. Salmon spawning



West Grand Lake Dam obstructs salmon migrations along the West Branch St. Croix River. St. Croix River Basin .

still takes place in the outlet, but it is restricted to relatively few fish which escape into the stream from the lake system or the hatchery facility at the outlet. The productivity of this outlet and its high potential as a spawning area are denied to the lake system above by the barrier dam at the outlet.

34. Fish passage facilities are not provided at the dam, but a fish screen is located just above the dam which is designed to prevent the loss of salmon over the dam and out of the Schoodic Lakes system. Warm-water fishes predominate in Big, Long, and Lewy Lakes and Grand Falls Flowage, all lying downstream from Grand Lake Stream. The original decision to provide a fish screen at the outlet of Grand Lake and the omission of a fish ladder at the dam were measures logically taken to separate the warm-water fishes of the Big Lake area from the cold-water fishes of the Grand Lake system.

35. Smallmouth black bass have become established in Grand Lake and other ponds in the Schoodic Lakes system. Their areas of dominance in this system are not well known, but it appears that salmon fishing has deteriorated, particularly in certain sections of Grand Lake and in the Sysladobsis Lakes area. Inasmuch as warm-water fishes are now found above the outlet dam the functions of the barrier and fish screen would appear to serve little useful purpose. In fact, it would seem to be desirable to eliminate the screen and provide an adequate fishway

over the dam. If salmon fishing is to be preserved or augmented in the Schoodic Lakes system, it would be advisable to utilize all features of the habitat which favor this species. Smallmouth bass are, of course, found in the outlet stream but their numbers do not appear excessive and their presence in the stream may be largely seasonal and composed of individuals from the Big Lake area. Removal of the screen at the outlet and construction of an adequate fishway would make it possible for lake salmon to utilize Grand Lake Stream for spawning. The lake area should benefit from the productive potential of this stream. It is doubtful whether many bass would ascend the fishway.

36. Another objectionable feature of the Grand Lake Stream area is the occasional large fluctuations in releases from the outlet dam. Fluctuations are, of course, expected from a project designed for flow regulation, but retardation of flows out of Grand Lake appears rather complete on occasion. Flows of 17 to 25 cubic feet per second for a two-week period during April and May 1948 were extremely low, especially for the spring season. The gauging station is located downstream from the fish hatchery at the lake outlet, so these minimal flows apparently include hatchery waters. Flows must have been nearly nonexistent between the dam and the hatchery outlet. Much greater discharges are provided during the normally dry summer period. These greater flows are beneficial, but they often exceed the capacity of the



Salmon spawning and nursery portion of Grand Lake Stream with a
Maine State salmon hatchery on its bank. St. Croix River Basin .

stream bed. Less complete restriction of flows during the spring would undoubtedly increase the productivity of the stream.

37. Fishways have been constructed at most of the small dams in the headwaters of the basin. The dams at the Musquash Lakes, East Grand, Spednic, and Lambert Lakes all have fishways, as does the dam on Clifford Stream. The new dam on Tomah Stream is not a barrier to fish movements during most of the year. The fishway at Lambert Lake is in poor condition and is probably non-functional.

38. Little timber clearing has been carried out in the flowage area at the recently constructed dam on Tomah Stream. A fire hazard to the forest and its wildlife has been created at this location as a result of failing to clear the reservoir area. The dam at East Grand Lake does not comprise a hindrance to salmon spawning when the gates remain open. Flows pass directly through the structure at such times. This condition is especially beneficial during the spawning period of salmon, because the outlet is an important spawning site and vital to the economy of salmon fishing in East Grand Lake.

39. Effect of pollution. - Pollution in the St. Croix Basin is an important consideration only along the main river from Woodland to its mouth and along the river estuary. Below Woodland the river bed is fouled with wood and pulp wastes and the chemical condition of the water may be poor during certain periods. Fall-fish, smallmouth black bass, suckers, and pickerel are known to

inhabit the stream, but little fishing takes place. Holding boxes containing young Atlantic salmon were placed in the stream at several locations during July of 1949. The survival rate of the fish was high for the period of investigation except along the United States side of the river below Woodland. It should not be inferred from these experiments that conditions for fish life are generally satisfactory in the river. A brief period of high temperatures or toxic conditions could greatly diminish productivity and damages to the habitat are continuous.

40. The role of pollution in causing losses in value of the river fishery is a minor one at the present time, because dams prevent anadromous fishes from ascending the stream. The construction of adequate fishways would render it necessary to abate pollution in order to realize full benefits from the fishway program.

41. Control of warm-water fish. - The liberation of smallmouth bass into such waters as Spednic Lake and the Big Lake area has resulted in the establishment of some of the finest smallmouth bass fishing available in the northeastern United States. A biological and physical survey of these lakes has not been conducted by the Maine Department of Inland Fisheries and Game. Nevertheless, it appears certain that these lakes had advanced beyond the point of productivity for cold-water fishes long before the introduction of bass. Thus, in those lakes which offered marginal habitat for trout and salmon the bass introductions have been beneficial.

Doubtless a few brook trout and landlocked salmon still exist, at least seasonally, in the warm water ponds of the basin, but they will probably never again form a significant element in the fishery in these ponds.

42. In many cases smallmouth bass have penetrated, or were stocked, in lakes which provided high quality habitat for cold-water game species. These introductions sometimes followed deterioration of the natural habitat for trout and salmon through limitation of spawning areas by construction of dams, or otherwise damaging the cold water habitat. The pattern of fishing success in such instances has followed one of two directions. Either the trout and salmon fishery has been largely replaced by a good quality bass fishery or the trout and salmon fishery has deteriorated with only mediocre bass fishing developing.

43. Salmon and trout fishing in Spednic Lake has been superseded by smallmouth black bass fishing of excellent quality. A few salmon are still caught below the outlet dam, but for all practical purposes Spednic Lake provides only warm-water fishing. On the other hand, the establishment of smallmouth bass in the Grand Lake area apparently has had a varied impact. Salmon fishing continues good in Grand Lake proper, but it has suffered in the Sysladobsis Lakes and in other sections of the upper West Branch system.

44. One of the most pressing needs in the St. Croix Basin is a solution to the problem of retaining trout and salmon waters in a productive condition or returning them to that condition in the face of competition from warm-water species. The simple technique of stocking large numbers of trout and salmon, while refraining from stocking warm-water species has seldom been successful in reclaiming lakes for cold water fishing.

45. Management of lakes for fishing. - For maximum efficiency in managing lakes of a cold-water character, which are low in fish productivity due to competition factors, it is necessary to correct deficiencies in the existing habitat such as those caused by barriers across spawning and nursery tributaries. Regardless of the enforcement difficulties, management of waters on an individual basis requires the application and enforcement of laws on the same basis. General laws may prevail, but within the framework of these laws special statutes will be imperative for the proper management of individual waters. It appears inexplicable to devote large sums in raising and planting or otherwise nurturing trout and salmon in a body of water while at the same time protecting elements in the fishery which diminish the productivity of the environment for these choice species.

46. With regard to competition between desirable and less desirable species much basic information relating to the quality of various lakes in Maine has been acquired during the lake surveys conducted by the Maine Department of Inland Fisheries and

Game. 2/ This survey has extended to certain lakes in the St. Croix River Basin, and cognizance of the problems of dams and species competition has been afforded full recognition in the lake survey reports.

47. In applying management of individual lake waters on a basin-wide basis or a state-wide basis, it is desirable to classify all bodies of water according to their capacity to provide either cold or warm-water fishing. Following a determination of the general productive capacity of the lakes, it is necessary to select for restoration those lakes which offer the best opportunity to develop fishing for species in highest demand. Certain bodies of water fall into the category of presently productive cold-water lakes not seriously suffering from competition factors such as the Musquash Lakes. It has been determined that other ponds, such as Big Lake, should be managed to provide warm-water fishing. Between these two extremes are found certain ponds, such as Sysladobsis and East Grand Lakes, which are physically capable of sustaining a greater fishery for trout and salmon if small-mouth bass, white and yellow perch, and pickerel were held in check and eventually reduced.

48. It is often surmised, of course, that the re-establishment of a cold-water fishery in lakes suffering from considerable species competition from warm-water fishes is difficult. This

2/ Everhart, W. Harry and Bond, Lyndon H., et al., 1953, Maine Lakes, A Sportsman's Inventory, Maine Department of Inland Fisheries and Game.

assumption has had merit because of the practical difficulties involved. Accordingly, attempts to restore cold-water fishing has been confined largely to small bodies of water where the simple method of poisoning warm-water fish has been utilized.

49. In attempting to solve the problem of species competition in the basin and elsewhere in the State, it is vital to recognize that many physical and environmental factors, other than species competition, prevail against the warm-water species in a cold-water lake. In the habitat otherwise admirably suited to their needs, the cold-water species suffer only from species competition or from human disruption of the habitat. The inherent physical qualities of the lake are in their favor.

50. Among the factors which may operate against warm-water fish in a cold-water environment are low growth rates, poor spawning success, lack of inherent richness in the food chain for warm-water fish, and competition and depredation by cold-water fishes. There may exist a great volume of water in the deep, cold layers as compared to the volume in the warmer surface waters during the growing season, littoral areas and their fauna may be scarce, and water-level fluctuations may operate against warm-water species during and after spawning periods. There also may be found an excellent potential for salmonoid spawning in lake tributaries.

51. It is possible to increase the impact of the above factors through long-term management techniques. While less striking than the complete poisoning of the smaller ponds, these measures could effect lasting benefits. Possible techniques which could be employed are as follows: spot poisoning of spawning sites of unwanted species and destruction of littoral pockets, employment of increases in water-level fluctuations during and after spawning periods of undesirable fishes, removal of laws protecting certain species, and removal or poisoning of spawn at every opportunity. The above techniques should be coupled with such positive measures as improving the potential of cold-water spawning and nursery streams, making these streams available to spawning fish, and affording protection of laws on spawning streams of special productivity.

52. In general, the solution of problems emanating from dams, pollution, and species competition would go far toward aiding the fishery resources of the St. Croix Basin. Problems of lesser scope concern the management of individual water areas. One such difficulty is found at Spednic Lake. Many residents of Vanceboro are dependent, in part, on the recreation afforded at Spednic Lake. It appears that some sporting business is lost to the Canadian section of the lake, because the laws are much more liberal in New Brunswick.

COORDINATION WITH OTHER LAND AND WATER DEVELOPMENT

53. Plans for recreation development, pollution abatement, and certain features of the land-management plans would benefit the fish and wildlife resources of the basin. Adaptation of existing dams to fishery needs is desirable. At the present time there are no hydroelectric power, flood control or navigation measures under consideration affecting fish and wildlife resources.

FISH AND WILDLIFE PLAN

54. The plan for development of the fish and wildlife resources of the St. Croix River Basin is designed to bring about improved habitat conditions for the various species indigenous to the region. Elements in the plan would result in greater and more equitable utilization of these resources.

55. The features of the fish and wildlife plan are:

- a. Development of a coordinated program of wildlife management on the timberlands in the basin in cooperation with lumbering interests in order to assure a well-balanced management of areas of special value, such as deer-wintering sites.
- b. Development of attractive marsh areas in the basin for waterfowl and fur-bearing mammals.
- c. Continued vigilance with regard to deer poaching in the basin, with special emphasis on the possibilities of informing the public concerning the serious damages resulting from illegal hunting.

d. Construction of fishways at the three existing dams along the St. Croix River in order to facilitate runs of anadromous fishes.

e. Correction of fish-passage deficiencies at the several existing low dams in the basin, together with provisions for maintaining adequate minimum flows.

f. Increased emphasis on investigations seeking to determine the best methods of solving the problem of incompatible fish populations in the lakes of the basin.

SECTION X - RECREATION

THE RESOURCES

1. Natural features of recreation importance. - The St. Croix River Basin offers an unusual combination of land and water resources suitable and desirable for recreation. This easternmost drainage area within the New England-New York area contains a rather extensive network of lakes, ponds and streams which together comprise nearly 10 percent of the total area of the basin. Grand Falls Lake, Big Lake, Grand Lake, and the group upstream known as the Schoodic Lakes all within the West Branch drainage, are important features. The group of lakes known as Chiputneticook, which include East Grand and Spednic Lakes on the East Branch, are also important from a recreation standpoint.

2. The land is generally rolling to hilly with elevations exceeding 900 feet in only a few places. Greenland and Tomah Mountains and Spruce Peak which are located on the west shore of East Grand Lake, and Dill and Musquash Mountains, which rise a short distance north of the Grand Lake system, comprise the highest elevations. Musquash Mountain is the highest having an elevation of 1,238 feet.

3. With the exception of several marsh areas in the headwaters, the basin is largely forested with fair stands of second-growth hardwoods and conifers. The forest areas include a few

stands of virgin hardwoods, principally Rock Maple, estimated to be from 125 to 150 years old.

4. Several popular species of game fish are found in the lakes and streams including brook and lake trout, landlocked salmon, bass, perch and pickerel. The wildlife which inhabits the basin includes, among others, three species of big game, deer, moose, and black bear. Deer are particularly plentiful.

5. The portion of the basin above the junction of West Branch and East Branch is for the most part in a natural state verging on wilderness. It is a part of the Grand Lake wilderness which embraces most of the St. Croix drainage and extends into the adjacent Penobscot and Maine Coastal basins. The portion of this wilderness within the confines of the West Branch is remarkably undisturbed by man except for lumbering operations and fires. It is regarded highly by sportsmen for its good fishing in a real wilderness. It is also regarded highly by wilderness and nature enthusiasts. Similar conditions are found along the west shores of East Grand Lake and the Chiputneticook Lakes on the East Branch.

6. Historical and archeological features. - St. Croix Island, scene of the first French attempt at settlement in North America north of Florida, is treated in Section X of the Maine Coastal Basin report. Outside of the site of this early settlement there are no known sites or features of historical importance within the basin.



The East Branch St. Croix River downstream from East Grand Lake is an undisturbed stream in a natural setting and is an important spawning area for land-locked salmon. St. Croix River Basin .

PRESSENT RECREATION USE

7. General recreation. - The fishery and wildlife resources of the basin have for years been the principal recreation attractions both for the resident population and the non-resident sportsman. Several of the lakes are regarded highly by fishermen for their quantity and quality of fish which include both cold and warm-water species, and the general wilderness setting adds to their attractiveness. The lakes and streams have also been used to some extent for many years for canoeing. Two canoe routes have been charted over the watercourses. One originates in the headwaters of the St. Croix above East Grand Lake and traverses the river to Passamaquoddy Bay. The other traverses Grand Lake, Big Lake and Grand Falls Lake, while the tributaries of these lakes offer several side trips of varying lengths. This route connects with the St. Croix River route at the outlet of Grand Falls Lake. By means of foot or short highway portages, it is possible to extend canoe travel into portions of adjoining basins. Present use of the recreational resources is primarily in connection with fishing, hunting, canoeing and camping.

8. Private and commercial facilities and accommodations. - Facilities for recreation, which are limited, consist for the most part of sporting camps, boat liveries, cottages and guide services. These facilities and accommodations are located in the general vicinity of Grand Lake Stream and Princeton, both of which are

near the central portion of the basin, and at Danforth and Vanceboro in the upper part of the basin. Grand Lake Stream, at the outlet of Grand Lake, is the principal point of departure for fishermen, hunters, canoeists, and campers enroute to the remote points within the watershed.

9. Public areas and facilities. - Public recreation areas and facilities within the basin consist of seven campsites and lunch grounds established by the Maine State Forest Service. They are located along the lakes, shores and streams in the more inaccessible parts of the basin and are used in connection with overnight stops and for cooking meals. These sites have been established primarily as a fire protection measure by the State Forest Service. There are also two roadside picnic areas which are maintained by the State Highway Commission. Within the 17,000 acre Indian Township, which is owned by the State of Maine and held in trust for the Passamaquoddy Tribe of Indians, there have been developed limited facilities on the shore of Big Lake including a small picnic ground and camp grounds. Facilities include fireplaces, lean-to shelters, a spring for water supply, sanitary facilities and parking space for about 25 cars. This reservation is located just north of Big Lake and west of the St. Croix River.

10. Estimate of present use. - Visitor use of the resources in past years has been primarily in connection with fishing and hunting. The greater portion of this use comes from those non-resident

fishermen and hunters who have become acquainted with the basin and its features and who return each year during the fishing and hunting seasons. It is also used by the residents of the basin in connection with these activities. Over-all attendance and use figures are incomplete although on the basis of available data it is estimated that visitor use during 1952 was close to 18,000, which is nearly twice the present population of the basin. Total expenditure in connection with recreation during 1952 was about \$2,250,000. While lumbering and the manufacture of paper and wood products are considered the principal industries, it is apparent that recreation is important to the economy of the basin.

RECREATION NEEDS AND POTENTIALITIES

11. The general wilderness character of a large portion of the basin with its extensive forests, lakes, streams and marsh lands is ideal for camping, canoeing, fishing and hunting. This primitive condition can be attributed to a number of factors, including among others, the remoteness of the basin from population centers, its sparse population, land ownership in a few hands, location of access and through routes, and the lack of industrial development. The population, consisting of 9,000 permanent residents, is centered for the most part in the lower portion of the basin below the confluence of East and West Branches leaving large areas in the upper parts of the drainage uninhabited. The basin is considerably removed from the more heavily populated sections of Maine and from

the large metropolitan areas along the coast to the south, including greater Boston and New York, although U. S. Route 1 and State Route 6 provide access to and through it. The locations of these routes within the basin and the limited number of secondary roads leave large areas inaccessible by motor vehicle. Industry is confined to the lower portion of the basin in the towns of Calais and Woodland while the vast timber lands are owned by a few pulp and paper companies.

12. Present use does not point to the need for immediate expansion of accommodations or facilities. However, with the completion of present highway expansion programs including through routes and toll roads which will provide easy flows of traffic into and through the region, along with the rapid disappearance of wilderness areas in other parts of the country, it is reasonable to expect an increase in visitor use of the St. Croix River Basin. Development of power at nearby Passamaquoddy Bay could, if realized, have far-reaching effects on adjacent and nearby areas which include most of the St. Croix Basin. Planning for recreation use should be undertaken well in advance of expected use with a view to retaining the natural character of a large portion of the basin. The combination of features within the basin readily lends itself to specific types of use including camping, fishing, hunting, canoeing, nature study and closely related activities, and only the moderate and simple types of facilities and accommodations should be considered. It would be desirable to locate the principal recreation

developments, such as campgrounds, fishing and hunting lodges, and the necessary basin facilities such as roads and parking areas, in the peripheral area of the wilderness sections. Satellite areas with facilities for camping, boating, fishing and related uses could be located on the shores of the more prominent lakes such as Grand, Long, East Musquash, Lower Sysladobsis, and East Grand Lakes. Due to the general character of the surrounding lands relatively small acreages, ranging from 100 to 200 acres per developed area, would be sufficient for the facilities that may be required. Preservation of the wilderness conditions insofar as practicable either through acquisition, cooperative agreements with land owners, zoning measures or combinations thereof should be considered.

13. Although road and highway development and expansion are needed throughout the basin, it is important that their locations be planned so as to provide access to but not through the wilderness portions. A belt-line road with short spur roads leading to existing or proposed recreation developments is desirable. Existing Highways 1, 6 and 9 appear adequate to serve the need for such a circumferential road system. The short stretch of road leading from U. S. Route 1 to the community of Grand Lake Stream is a splendid example of a spur road arrangement.

14. There is a growing need for the preservation of wilderness areas throughout the country such as are found in the St. Croix drainage. An area selected for this purpose should contain natural

features of the best available quality that typify the lakes and wooded hills of the district. The area lying between the shores of Grand Lake and West Musquash Lake appears to contain these features. The excellent water quality and picturesque shorelines of these two lakes, the inspiring stand of giant old virgin hardwood trees at the upper end of West Musquash Lake, and the topography of the area in general combine to make it suitable and desirable for a wilderness preserve. An area of approximately 75 square miles should be considered for preservation. This would allow an adequate buffer or protective strip around the features to be preserved.

15. It appears that additional highway roadside picnic areas will be needed along principal routes (U. S. 1 and State 6) to meet the anticipated increase in tourist travel and to supplement the two established wayside areas. These areas should be located to take advantage of some scenic feature.

16. Provisions should be made for public access to lakes and flowages of the basin for fishing, boating, and related water recreation uses in order to afford greater opportunities for public use of these features. Establishment of public easements along rivers and streams for fishing purposes might also be desirable.

17. Taking into account the various factors which have a bearing on use of the recreation attractions, particularly accessibility, population distribution, climate, and transportation,

it is estimated that the annual visitor use of the resources of the basin would approximate 58,000, if the resources were to be developed along the lines as outlined herein. This represents an increase of 40,000 over the estimated present use. This increase in use could be expected to raise the annual spending in connection with recreation to approximately \$4,300,000, an increase of \$2,050,000 over the present estimate of expenditures.

PLAN FOR DEVELOPMENT OF RECREATION

18. General discussion of the plan. - The plan is offered as a guide for further development of the resources of the basin for recreation purposes. It is based upon present and estimated future needs and is designed to provide for the protection of important natural features, expansion of existing areas and facilities and the development of additional areas.

19. The plan deals with the general phases of planning and is not intended to present detailed estimates or to confine developments to specific locations. These details would logically follow the adoption of a general development plan.

20. Cooperation of all conservation agencies dealing with land and water resources is essential to the execution of the plan in order to protect the resources from impairment and encroachment, particularly those agencies dealing with fish and wildlife conservation, pollution control, and forest management. Current programs of these agencies should be coordinated with the plan for recreation development.

21. The plan provides for:

a. Establishment of a wilderness tract through acquisition, zoning, or cooperative agreements with property owners. The area lying between West Grand and West Musquash Lakes appears to contain the features desired including both land and water features, excellent vegetative cover, geological formations, and fish and wildlife. Approximately 48,000 acres would be desirable. This would allow adequate buffer for protective purposes.

b. Development of four campgrounds, each with lake frontage to provide opportunities for tourists and vacationists who prefer camping to the more formal types of overnight accommodations. Each development would have the necessary facilities including access roads, parking space, campsites, sanitary facilities, waterfront equipment and trails. Location and approximate acreage are as follows:

- (1) At West Grand Lake, 500 acres
- (2) At Lower Sysladobsis Lake, 150 acres
- (3) At Pleasant Lake, 200 acres
- (4) At East Grand Lake, 300 acres

c. Construction of approach roads to the proposed sites, approximately 40 miles.

d. Development of five wayside areas within the basin along U. S. No. 1 and State No. 6. Locations for these developments should be selected to take advantage of scenic features and

should include picnic tables, fireplaces, parking areas, drinking water, and sanitary facilities. Approximately 40 acres required.

22. Estimated development costs, as well as costs of annual operation and maintenance, for public area recreation developments are presented in Table 19 . These costs, necessarily of a preliminary nature, are based on those of comparable developments and operations rather than upon detailed analysis of the sites listed. The total cost of development includes costs of both land acquisition and physical improvements.

23. Benefits of the plan. - Both tangible and intangible benefits would result from further development of the resources along the lines set forth in the recreation plan. Tangible benefits are represented by monetary expenditures of visitors using the recreation resources, areas and facilities. These benefits are estimated to be about 10 percent of the estimated increase in gross expenditures, as reflected in Paragraph 17, or about \$205,000 annually.

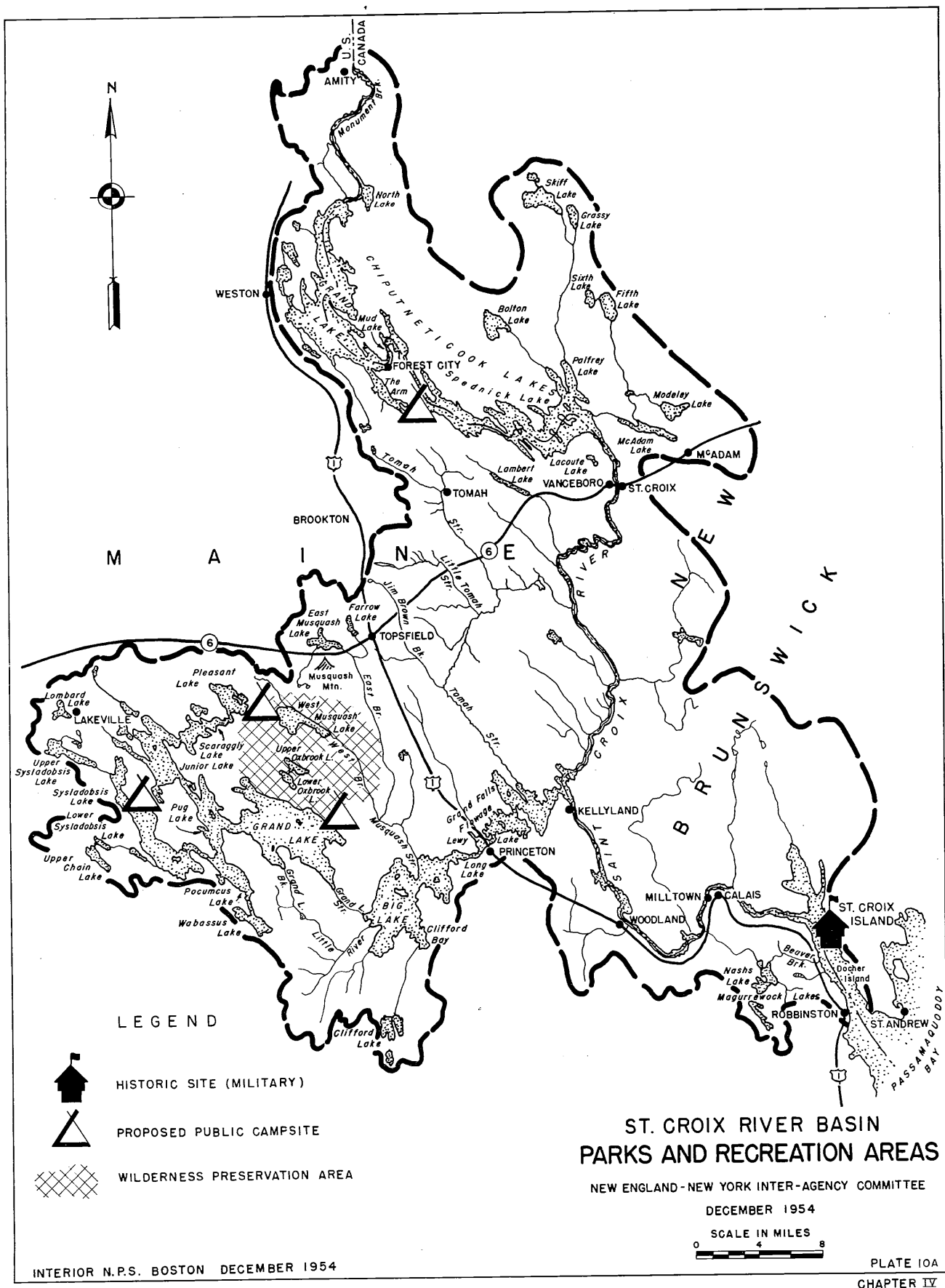
24. Intangible benefits are those which cannot be computed in monetary terms. In connection with recreation, they constitute contributions to the physical, cultural and spiritual health of individuals as a result of participation in outdoor recreation activities. By increasing the opportunities for recreation through provision of recreation areas and facilities, more people would be benefited.

Table 19 - Estimated costs of recreation development,
St. Croix River Basin

Area	*Total first cost of land and physical improvements	Annual operation and maintenance cost	**Total annual cost including interest and amortization
Wilderness tract (48,000 acres)	\$ 340,000	\$ 8,400	\$ 26,855
<u>Developed areas</u>			
West Grand Lake (500 acres)	99,000	2,400	7,973
Lower Sysladobsis Lake (150 acres)	51,200	1,900	4,679
Pleasant Lake (200 acres)	66,600	1,950	5,565
East Grand Lake (300 acres)	82,400	2,100	6,572
<u>Approach road development</u>			
Total 40 miles	645,000	8,000	43,011
Highway wayside areas (5) required. Approx. 8 acres each	25,350	500	1,775
Total	\$1,309,550	\$25,250	\$96,430

* Includes the costs of both land acquisition and physical improvement.

** Total development costs amortized for a period of 25 years at 2-1/2 percent plus annual operation and maintenance costs.



SECTION XI - LAND MANAGEMENT

1. From the standpoint of land management the St. Croix River Basin is an integral part of the Maine Coastal Area. For this reason, the discussion of land use in this basin is included in the overall treatment of the subject of land management in Section XI of Chapter X - Maine Coastal Area.

SECTION XII - MINERALS

INTRODUCTION

1. Glacial material covers most of the bedrock of the St. Croix River Basin in Maine, and an estimate of the mineral resources other than sand, gravel, and peat must be based on inferences. As yet no metallic mineral deposit has been found, although large, hitherto unsuspected base metal deposits have recently been found near Bathurst, New Brunswick, and nickel and copper minerals occur in New Brunswick near Calais, Maine.

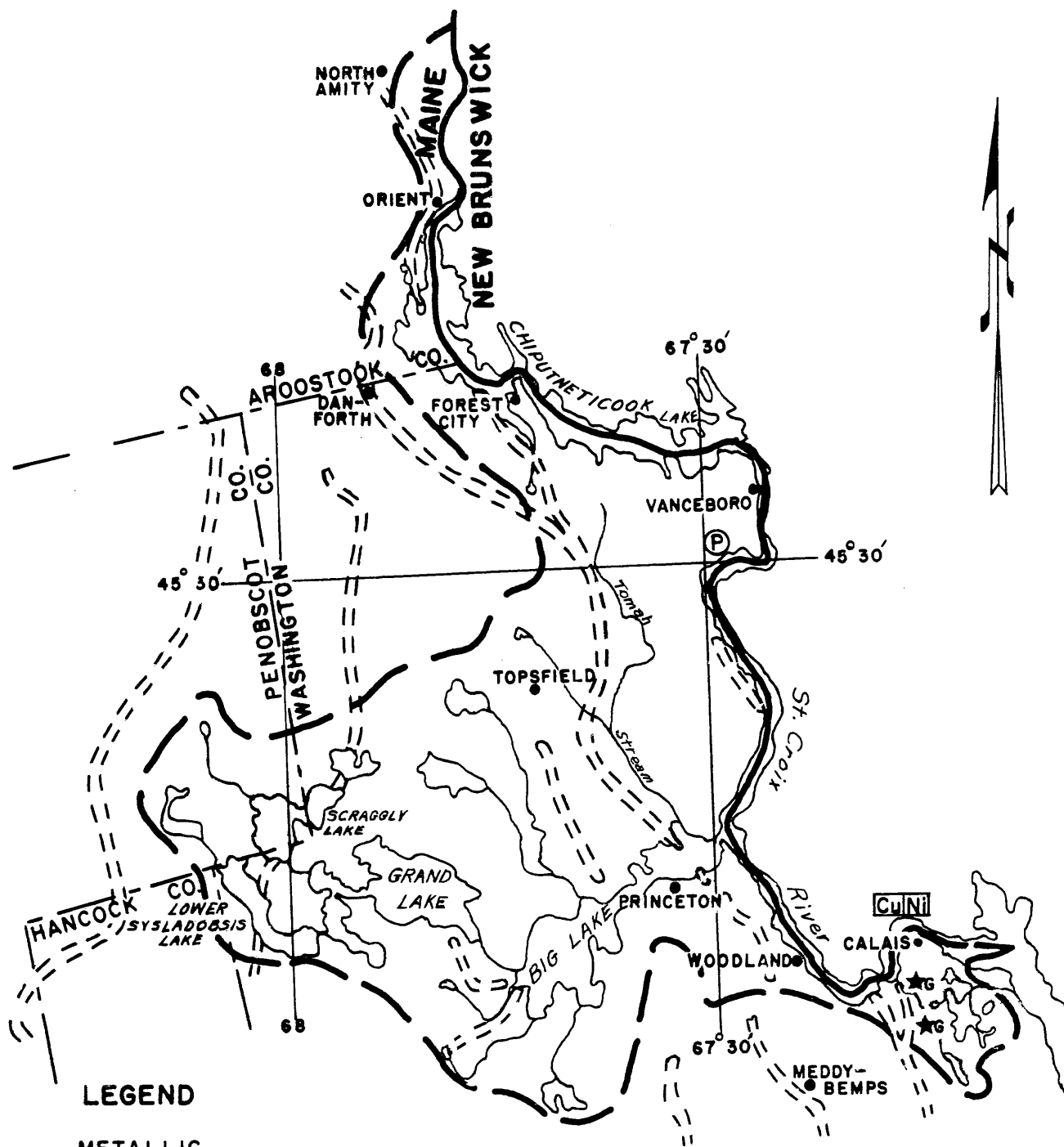
2. Intensive geologic investigations and detailed geologic maps have not been made of the basin. In 1933 a Preliminary Geologic Map of Maine, based only on reconnaissance studies, was published. It indicates that the bedrock of the basin consists chiefly of northeasterly trending belts or strips of quartzite, argillite and slates of Early Paleozoic age. An irregular, southwesterly trending belt of granitic rock crosses the international boundary between Vanceboro and Orient and extends southwesterly from Vanceboro for a distance of 60 miles. Near the 68th meridian this extension, as shown, attains a width of 12 miles. This belt of igneous rocks extends northeastward from international boundary, to the vicinity of the new base metal discoveries in New Brunswick.

3. Most of the bedrock is overlain by glacial deposits and some marine sand and clay. Glacial till (unsorted silt, sand, pebbles, cobbles, and boulders) is covered in places by outwash deposits consisting of silt, sand and gravel. The glacial deposits along the

the St. Croix river valley are overlain in places by marine clay and sand.

4. Between 1930 and 1933 Leavitt and Perkins (1934) made a survey of the occurrence and quality of the highway materials of Maine in the course of which many samples of the sand and gravel deposits were taken and tested. The glacial geology of the St. Croix River Basin was summarized and a map was compiled showing the distribution of the eskers, which are the most important sources of coarse granular materials.

5. In 1953, a series of airborne magnetometer flights were made by the Aero Service Corporation of Philadelphia, under contract with the State. The results of this project, which covers portions of the eastern part of Maine have been placed in the open file of the State Survey at Orono. Of these surveys Trefethen says: (1953, p. 5-6) "It should be emphasized that these magnetic surveys do not in general locate ore bodies. They do narrow the target somewhat for certain types of ore bodies, and aid in the delimitation of certain geologic bodies; for example, it should be possible from these maps to localize granites, and distinguish between metamorphic and sedimentary rocks, and to distinguish basic from acidic igneous rocks. In this connection, it is interesting to note the extensive magnetic work that has been done in New Brunswick. In a state as large as Maine, it appears that this type of aerial survey is an excellent means for selecting specific areas for follow-up ground work." Of the two areas flown in this series of airborne



LEGEND

METALLIC

Copper, Nickel

CuNi

NONMETALLIC

Peat

(P)

Stone, dimension

Granite

★G

ESKER "Horseback"

Potential source of
sand and gravel.

Because they are so numerous few locations of peat
and no locations of clay, sand and gravel deposits
have been shown. In most cases the symbol for
stone indicates a locality rather than an individual
occurrence.

MAP
OF

ST. CROIX RIVER BASIN

SHOWING

LOCATIONS OF MINERAL DEPOSITS

NEW ENGLAND-NEW YORK INTER-AGENCY COMMITTEE

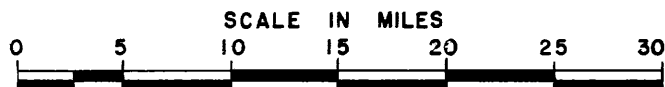


PLATE II
CHAPTER. IV

magnetometer flights, the Forest City area covered a strip about $7\frac{1}{2}$ miles by 45 miles, between North Amity and Princeton across the narrow northern extension of the St. Croix River Basin. The Meddybemps area, of rhomboidal outline, has an area of about 200 square miles and lies to the southwest of Calais.

MINERAL COMMODITIES

6. Sand and gravel. - Sand and gravel are the only mineral commodities produced in the basin. The small production supplies road metal and concrete aggregate for local use. Leavitt and Perkins (1934) mapped three large eskers crossing the swampy part of Washington County and note that "in Washington County the eskers become much larger; and instead of being rather small valley forms, they are great embankments crossing the broad swampy plains of this region."

7. Leavitt and Perkins, (1935) classified the Maine gravels according to lithological content. The gravels of northern Washington County are shown (Leavitt and Perkins, 1935, p.189) to be composed essentially of quartzite and felsite. Specific samples of much of the material were considered satisfactory. Not all of the material from the eskers was of good quality. The quality of the gravel appears to have averaged higher than that of the sand.

8. The immense volume of material in the eskers assures sand and gravel for the foreseeable future, but to meet specifications requiring high quality material selective pitting and washing may be necessary.

9. Copper and nickel. - Copper and nickel minerals occur in a basic igneous rock that crops out at St. Stephen, New Brunswick a short distance north of Calais, Maine as shown on Plate 11. After World War II this occurrence was drilled by the International Nickel Company, but no results have been made public. The same igneous rock probably extends under Calais, Maine, but no occurrence of copper and nickel minerals has been reported in this area.

10. Granite. - No detailed information concerning the granite production and resources of the basin is available. The geologic map shows a large area southwest of Calais to be underlain by granite. Probably such rock as has been quarried has been used locally.

11. Peat. - Small peat bogs have been found in the swampy areas, but none are being worked. No detailed information on the deposits is available. Unless deposits of high or peculiar quality are discovered, peat from bogs in this basin will continue to be of local interest only.

MINERALS PLAN

12. Quadrangle mapping of selected areas should be started.

13. Airborne magnetometer surveys of other areas in the St. Croix River Basin should be considered, having in mind the part played by airborne and ground magnetometers in the recent significant discoveries of base metals in New Brunswick, where the general rock relationships are similar.

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SECTION XIII - INSECT CONTROL

1. This section provides information on the present status of insect-borne diseases, insect disease vectors and pest insects in the St. Croix River Basin; data to determine the need for approximate costs of control programs; and the benefits that may accrue from such control programs. Insects adverse to public health are considered in two categories: (1) those that are capable of being disease carriers (vectors), and (2) those pest insects that reduce the physical efficiency and comfort of man and affect his economic status.

PRESENT STATUS OF INSECTS ADVERSE TO PUBLIC HEALTH AND THEIR CONTROL

2. Disease and vector* problem. - Malaria has probably never been endemic in the St. Croix River Basin despite the presence of war veterans who returned with disease. Anopheles quadrimaculatus, the malaria vector, which occurs in moderate numbers in the southwestern portion of Maine, has not been recorded from this basin. Therefore, malaria is not considered a public health problem.

3. Eastern equine encephalitis is not known to be a public health problem in the basin. Several species of mosquitoes occurring in the basin which may be implicated in the possible transmission of the disease are: Aedes vexans, A. triseriatus, A. atropalpus, A. sollicitans, Mansonia perturbans and Culiseta

*An insect which carries and transmits disease-causing micro-organisms.

melanura. One or more of these species is common in a wide variety of habitats.

4. Rocky Mountain spotted fever, a tick-borne disease, has not been reported as having been acquired within the basin and the vector, Dermacentor variabilis, the American dog tick, is not endemic in the basin. It is not at present a public health problem.

5. Tularemia has not been reported in the basin and it is questionable if it is endemic in this basin. It is not considered to be of public health importance at the present time as an insect-borne disease. It is transmitted to some extent in other parts of the country by ticks, deer flies and certain other biting insects, but there are no records to indicate such transmission to man in this basin. Many species of deer flies are common in this basin, but none which occur here has been implicated in the transmission of tularemia.

6. The pest insect problem. - Pest mosquitoes, and to a lesser extent, black flies, punkies (sand flies, no-see-ums), deer flies and greenheads are a source of annoyance and discomfort in many parts of the basin.

7. Mosquitoes. - There are 31 species of mosquitoes known to occur in the basin of which 21 are ordinarily troublesome as pests.

8. A number of early spring Aedes develop in temporary pools in forest and grassland in early spring and are important pests. The principal species are: Aedes aurifer, A. communis, A. excrucians, A. fitchii, A. implacabilis, A. intrudens, A. punctor, A. stimulans

and A. trichurus. They are pests principally during the day and early evening. Temporary pools favorable for development exist over a considerable portion of the basin.

9. A few Aedes mosquitoes develop not only in the spring in temporary pools, but also develop intermittently or continuously throughout the summer in certain other types of water. Aedes canadensis and A. cinereus are important pests in this category. Two additional species, A. sticticus and A. vexans, develop in large numbers in isolated pools following receding floods. A. vexans is the major pest of this group, not only because it migrates up to three miles or more from its place of development, but also because it develops in enormous numbers and has an unusually wide range of breeding places.

10. Aedes sollicitans, the salt marsh mosquito, develops sparingly along the coast in salt marshes flooded by excessively high or moon tides. A. cantator breeds in bordering brackish pools.

11. The Northern House mosquito, Culex pipiens, is an urban pest of moderate intensity throughout the summer months, biting during the evening and at night. It develops in water in barrels, cans, fish pools, quarries, street drains and in slow flowing streams and ponds polluted with garbage, sewage, and other filth. Mansonia perturbans may be a bad pest locally during the summer.

12. Black flies. - Three species of black flies, Prosimulium hirtipes, Simulium venustum and S. tuberosum, are the principal pests of this group, although about 14 species are known from Maine. They develop solely in flowing streams, principally in fast-flowing streams.

13. Deer flies and horseflies. - A large number of species of deer flies and horseflies occur in the basin. Several species of the genus Chrysops (deer flies) are pests during the daytime inflicting painful bites. They are solitary in habits and ordinarily not many attack at one time. They do not constitute a public health problem equal to that produced by the mosquitoes, punkies and black flies. The larvae develop sparingly in a wide variety of habitats. The Greenhead fly, Tabanus nigrovittatus, occurs sparingly along the coast in the salt marshes.

14. Punkies. - Punkies, principally Culicoides obsoletus, are bad pests in the northern part of the basin. Biting occurs predominantly in late afternoon. In heavily infested areas, they bite by the hundreds and in these densities create a public health problem. Little is known about the habitat in which they develop.

15. The active insect season varies from approximately 110 days in the upper reaches to 150 days at the coast. The biting insects of major importance have a season extending from early to late May through late July or early August followed by a rapid decrease, thereafter, and terminating by late August or early September.

During this period, the mosquitoes reach their greatest numbers in late May, June and July. The black flies first appear in late April, May or early June and continue through late June, July and August. The punkies appear principally in late June and July. Ticks of importance to man are absent in this basin.

16. A summary of representative collection sites and approximate densities of the important pest species in the basin is given in Table 20.

Table 20 - Approximate densities of important pest species,
St. Croix River Basin

Locality	Mosquitoes:Black flies:Deer flies:Punkies:Greenheads				
Calais	5	4	0	0	0
Grand Lake Stream	0	0	0	6	0
Kellyland	6	6	0	6	0
Moosehorn	0	0	0	6	0
Princeton	6	6	4	6	0
Woodland	4	4	4	4	0

17. The figures in Table 20 represent the relative density of the pest insect population. On this scale the number 10 would represent the maximum number of pest insects encountered in any given area in the entire New England-New York area. Such conditions represent unbearable situations. Zero represents the absence of insects or extremely light densities.

18. Table 21 lists representative population centers where the intensity of the problem is believed severe enough that the desirability of pest control may be considered.

Table 21 - Population centers where insect control programs may be desirable,
St. Croix River Basin

Locality	Intensity of problem	Insects primarily causing problem	General type of control
Calais	5	Mosquitoes Black flies Punkies	* Larviciding and/or adulticiding Adulticiding
Princeton	6	Mosquitoes Black flies	Larviciding and/or adulticiding
Woodland	5	Mosquitoes	Larviciding and/or adulticiding

* Larviciding - killing insects in the larval (immature) stage with insecticides.
Adulticiding - killing insects in the adult or mature stage.

19. The figures in Table 21 represent the approximate intensity of the pest insect problem based upon the relative density of the insects, as well as upon the size of the population to be protected and the type and extent of the control work involved. The number 10 represents the worst problems in the New England-New York area where conditions would be unbearable. Zero would represent no insect attacks or only very rare annoyances. A figure between 5 and 6 represents the point at which possibility of a control program is ordinarily considered worthy of consideration. However,

these data are limited in their utility in giving only a basis for strongly supported generalizations on area pest problems. Additional site surveys will be required by competent personnel for determination of necessity and type of control program. During late May, June and early July, data indicate that the pest insect populations are at a level at which residents and vacationists at camps and resorts must seek protection against their attacks. The major accomplishment from control work would not only be towards the comfort of the local residents, but an increase in recreational income may also be expected.

20. No organized control program appears feasible in the sparsely populated portions of the basin. An added influx of tourists may be expected where the insect problem presently discourages visits to the vacation areas. Owners of camps and resorts will often find it profitable to consider limited control work such as larviciding, ditching or filling or temporary adulticiding in the immediate vicinity of their property.

21. No known insect control projects are in operation within the basin at the present time although there have probably been some localized, temporary projects undertaken in and around a few camps and resorts, especially during severe outbreaks of pest insects.

BENEFITS AND COSTS OF INSECT CONTROL

22. Because no known projects have been in operation from which costs and benefits can be calculated, estimates must be based on the nearest applicable data where such evaluations have been made.

23. The annoyance produced by biting insects in this basin and other portions of northern New England is well known. However, the problem of specifically evaluating the influence is difficult. Public health insect control benefits are generally classified as intangible which are difficult or impractical to measure in terms of accurate monetary benefits. It is highly improbable that accurate data can be obtained on medical expenses and man-hours of work lost as a result of insect attacks. It is even more difficult to assign monetary evaluation to benefits derived from the mere freedom from insect attacks by the inhabitants and workers of the basin where no actual medical expense or work loss is involved, although these benefits are probably the most important of all.

24. Insect attacks affect recreational income by a reduction of length of the tourist season and by a reduction in the use of recreational facilities. A possible means of partially evaluating tangible monetary benefits can be made with some degree of accuracy by a measurement of these effects of insect attacks upon the recreational income. Numerous reports from resort operators, State Park superintendents and residents, as well as from studies made in other localities, indicate that a five percent increase in patronage may

be expected after the biting insect problem is lessened and time is allowed for this information to reach the prospective tourists. A yearly average cost for temporary pest insect control in rural camps and resorts is estimated to be \$400 per unit over a period of years. A yearly average cost for the control of pest and/or vector insects in the St. Croix River Basin where organized community projects could be operated is estimated to be \$2,500 yearly over a period of years. The approximate total number of persons who would benefit from insect control programs is 11,029.

EFFECTS OF WATER RESOURCES DEVELOPMENTS ON INSECTS

25. Nearly every species of insect of public health importance in the basin develops in water. Studies in various parts of the United States have shown that additional insect problems frequently arise because of habitat alterations resulting from development of water resources and that in a large measure, these problems can be minimized or even prevented if specific consideration is given to them during the planning and construction phases of the projects. In this basin, extensive watered areas and areas in such localities are subject to mosquito, black fly, punkie and similar infestations.

26. Wildlife areas of a type favorable for insect production, such as shallow water impoundments, should be located preferably three miles from recreational areas, urban and suburban developments, since the flight range of practically all insects of public health importance in this basin is generally less than three miles.

If the above type of development is planned closer than three miles and a potential insect hazard is found inherent in the development of the project, the developing agency and the appropriate public agency engaged in insect control should insure the carrying out of required insect control measures. There should be provision made in the plans for the evaluation, prevention and control of insect problems associated with the individual project.

27. It has been found that in some areas the construction of impoundments for wildlife habitat has resulted in increased mosquito breeding. Trees, brush and debris inundated by the impoundment were not removed and their accumulation along the shores created ideal situations for mosquito breeding. These unkept shorelines created a vegetative and debris protection equal to that occurring during the spring in the average swamp and a much more favorable breeding condition during the summer. If the impoundments are to be used for wildlife, as well as for recreational purposes, provision should be made to insure a minimum of insect breeding.

28. The development of farm ponds with proper consideration for controlling insect production would not increase the public health nuisance problem. It has been found that insect production is at a minimum if the following measures are considered during the planning of farm ponds:

- a. Some of the larger ponds should be stocked with fish.
- b. It is also desirable to have three-fourths of the pond

area at a depth of six to eight feet and the elimination of shallow portions is encouraged.

c. Clean shorelines should be encouraged with the removal of woody vegetation prior to pond building.

d. In ponds stocked with fish, growth of aquatic plants is discouraged by fertilization of the pond which increases plankton, which in turn decreases sunlight penetration, which in turn decreases aquatic plant growth.

e. The constant agitation at the shoreline and in shallow water by livestock, ducks, or other animals helps to discourage insect breeding.

f. Ponds periodically pumped dry or down to a level below the grassy edges of the banks would be practically free of mosquitoes and if not filled up too rapidly would probably discourage the development of horseflies and deer flies.

29. In developing recreational facilities along the shores of Grand Lake, Long Lake, East Musquash Lake, Lower Sysladobsis Lake and East Grand Lake, consideration should be given to the potential insect breeding areas in the vicinity and their effect upon visitors. Insofar as possible, they should be located where public health insect production potential is low and where control can be effectively carried out when necessary without undue adverse effect upon wildlife.

CONCLUSIONS

30. a. Epidemiological records indicate that vector-borne diseases do not constitute a public health problem at the present time although vectors of several human diseases are present.

b. Of the many pest insect groups present in the basin, the mosquitoes constitute the principal pest problem, followed by black flies in importance. All groups of pest insects, except ticks, reach densities which constitute a problem in some rural camps. Control measures in these instances would materially reduce the incidence of these pests.

c. The yearly cost for the entire basin to control the major pest insects in urban areas is estimated to be \$2,500. Yearly cost for control in camps and resorts is estimated to be \$400 per camp or resort.

d. Benefits derived from pest insect control are usually considered intangible. However, it is estimated that a slight increase in recreational income could be expected as the result of pest insect control in resorts and camps.

e. Farm ponds and wildlife areas may create a public health problem from the standpoint of increased insect production unless precautions against creation of insect habitats are included in the planning and construction phases of these water areas.

f. Entomological surveys at proposed farm ponds and shallow water sites should be conducted on each specific site as the actual plans for development take place. This is particularly important if these developments are constructed near recreational areas and/or population centers.

INSECT CONTROL PLAN

31. The plan for the control of insects adverse to public health is as follows:

a. Conduct or continue studies and investigations especially of black flies, deer flies and punkies and provide consultation service to guide control programs.

b. Advise resorts, camps and other recreational interests, and urban communities with an insect-pest problem to seek the technical guidance of trained and experienced personnel before initiating control measures.

c. Provide for preventive and control measures against vector and pest insects in the planning and construction stages of water resource developments, especially when such developments would be located within three miles of existing or anticipated centers of population or recreational areas. In the event potential hazards are found inherent in the development of a project, the planning agency and the agencies concerned with the control of insects adverse to public health should (1) select appropriate measures for prevention or control of such hazards and (2) insure

the carrying out of required measures by making necessary provisions in the project.

d. Maintain limited entomological surveillance periodically at certain development sites to determine the effects of the project and its operation and maintenance on insect populations, and to determine when additional insect control measures may be necessary.

e. Provide aid in the evaluation of the vector and pest insect problems in connection with projects or programs within a State or on Federal property.

f. Foster liaison among agencies charged with the control of insects adverse to public health during the planning of public control programs.

g. Provide assistance to planners of recreational areas so that insofar as practical and possible, these areas would be located where the vector or pest insect production potential is low and where control can be effectively instituted when necessary without undue adverse effect upon wildlife; and so that wildlife areas of a type conducive to insect production would be located preferably three miles or more from recreational areas and urban and suburban developments.

SECTION XIV - COORDINATED BASIN PLAN

GENERAL DISCUSSION

1. The St. Croix River is an international stream throughout its entire length, forming part of the boundary between the United States and Canada. Two-thirds of the basin's area of 1,635 square miles are in Maine and one-third is in New Brunswick, Canada. This study has been confined to the United States. More than one-tenth of the area in Maine is in lakes and streams. Nearly all of the land is covered with forests which are sources of pulp wood and lumber. The streams, lakes and forests are used for hunting and fishing and wilderness recreation.

2. The basin is sparsely settled. About 70 percent of the 9,400 United States inhabitants live in the towns of Calais and Woodland, Maine which are located on the lower river about 20 miles upstream from Passamaquoddy Bay. Calais produces wood products and shoes and is the center of the food processing industry of the area. Woodland is the site of a large pulp and paper mill. An outstanding feature of the basin is its semi-wilderness character. The greatest need is for measures to preserve the excellent hunting and fishing conditions.

3. Storage and stream flow regulation. - Useful storage in the basin amounts to nearly 600,000 acre-feet. It is used primarily as a source of power and for log-driving. Stream flow is now fairly well regulated.

4. Water supply. - Surface water sources are adequate for all water supply needs for the foreseeable future. Any increased utilization of the main stream below Woodland, Maine for public and industrial water supply would require pollution control measures. Approximately half of the ground water supplies presently available in rural areas are not adequate and better methods of development are needed.

5. Pollution control. - Most of the lakes and streams of the upper basin are free of pollution. Maintenance of present high quality waters through stream classification has been accomplished but correction of the serious pollution below Woodland, Maine requires pollution control measures.

6. Flood control and drainage. - The natural storage provided by existing lakes and marshes reduces rapid run-off. Flood control measures are not justified at the present time. There are no drainage problems.

7. Power development. - The river is regulated by about 600,000 acre-feet of existing storage which is utilized chiefly for power generation and log-driving. Three existing industrial and utility power developments, with a total mechanical and electrical capacity equivalent to about 22,000 kilowatts, utilize 122 feet of the available head in the lower river. The power needs of the area are supplied by public utilities of Maine and New Brunswick. Of 23 sites in the basin investigated in detail for hydroelectric power development, none proved economically feasible under present conditions.

8. Navigation. - The navigation channel from Passamaquoddy Bay to Calais is used principally for the transportation of fuel oils, gasoline, other petroleum products, and fish. The existing navigation project is adequate for present needs.

9. Fish and wildlife. - The most important need of this basin is the preservation of its excellent hunting and fishing resources. In certain lakes, suited to the production of popular cold-water fishes, these species have been displaced by competitive fishes better suited to other waters. Research and management are required to restore cold-water fish populations in these lakes and ponds. In other lakes, better suited to warm-water fishing, there is need for continuing investigations into the quality of the fishing. Close cooperation between landowners and the agencies concerned with forestry, and fish and wildlife is needed in order properly to manage the game resources, especially the deer herd.

10. Recreation. - Recreation in this basin consists largely of hunting, fishing, camping and canoeing. In view of the increasing demands for recreation in wilderness areas it is important that some portions of the basin wilderness be preserved for that purpose. Approach roads, appropriate camping facilities and related services are needed.

11. Land management. - The land management and forestry problems and needs of this basin are discussed in Chapter X, Maine Coastal Area.

12. Minerals. - Further geologic investigation and mapping are needed. Discovery of nickel and copper deposits in New Brunswick, Canada, not far from Calais, Maine suggests the advisability of further investigation within the United States portion of the basin where similar geologic conditions are known to exist.

13. Insect control. - At present, insect vector diseases are not considered to be of public health significance although the vectors of these diseases are present in the basin. Control of pest mosquitoes, black flies and punkies is needed in certain parts of the basin where these pests reduce the physical efficiency and comfort of man and affect his economic status through a reduction of use of recreational resources.

VIEWS OF LOCAL INTERESTS

14. A public hearing by the Committee, held at Augusta, Maine on June 12, 1952 afforded local interests an opportunity to express their views with reference to the procedures and objectives of the regional survey and to bring to the attention of the Committee any resource problems which should be considered. Those who appeared generally favored State and local, rather than Federal, development and improvement of the natural resources. In regard to participation by the Federal Government, it was suggested that its activities be limited to the fields of planning and research. General requests were made for erosion control.

14a. When the survey was nearing completion and tentative findings of the Committee had been drafted, additional public hearings were held in order that the Committee might obtain the views of interested parties on the tentative findings. Public hearings on this chapter and other chapters on the river basins of Subregion "A" were held at Berlin, New Hampshire on November 10, 1954, and at Augusta, Maine, on November 11, 1954.

14b. Those who appeared made no comments which dealt specifically with the content of this chapter. Comments of general applicability to all the river basins of Subregion "A" are summarized in Chapter II. The views expressed by those who appeared and the views expressed in written statements have been considered by the Committee in the preparation of the report.

FEATURES OF THE COORDINATED BASIN PLAN

15. Upon the basis of the inventory of the land, water and related resources of the St. Croix River Basin and the measures required for their conservation, development and utilization, a Coordinated Basin Plan is presented below. The details of the several measures are set forth in Sections III to XIII, inclusive of this Chapter. The principal features of the Coordinated Basin Plan are as follows:

a. Storage and stream flow regulation.

No projects for additional storage.

b. Water supply.

(1) An investigation to determine the ground water potential and the most economical methods of obtaining dependable ground water supplies. Estimated cost \$10,000.

(2) A study of the trends of supplemental irrigation water demands. Estimated cost \$500 per year.

c. Pollution control. -

Installation of facilities for treatment or disposal of municipal, industrial and private wastes. In the absence of stream classifications established by the State Legislature of Maine which are required for a definitive plan for control of pollution originating in the United States portion of the basin, Provisional Plan C as described in Section V is offered as one of several possible plans to serve as a guide or frame of reference in planning water resource development. The estimated total first cost is \$1,569,000. Provisional Plan C is summarized as follows:

(1) Municipal primary sewage treatment facilities at two communities.

(2) Individual subsurface sewage disposal facilities at Robbinston.

(3) Industrial waste treatment facilities at one pulp and paper mill.

d. Flood control and drainage.

(1) No projects for flood control or drainage.

(2) Improvement of the warning service to give timely notice of flood threats.

e. Power development.

No projects for additional hydroelectric power.

f. Navigation.

No projects for additional navigation improvement.

g. Fish and wildlife.

(1) Development of a coordinated program of wildlife management in cooperation with lumbering interests.

(2) Development of marsh areas for waterfowl and fur-bearing animals.

(3) Continued control of illegal hunting, with consideration of instituting public information programs to curb such practices.

(4) Construction of fishways at three existing dams on the St. Croix River to permit runs of anadromous fishes. Maintenance of proper fish passages at existing low dams and provision of adequate minimum flows.

(5) Investigation of best methods of solving the problem of incompatible fish populations in the lakes of the basin.

No estimate of the cost of the fish and wildlife features of the Coordinated Basin Plan has been made.

h. Recreation.

(1) Establishment of a wilderness tract of 48,000 acres. Estimated first cost \$340,000.

(2) Development of four camp grounds, with lake frontages. Estimated first cost \$299,000.

(3) Construction of approximately 40 miles of approach roads. Estimated first cost \$645,000.

(4) Development of five wayside areas, 40 acres. Estimated first cost \$25,000.

i. Land management.

See Section XI, Chapter X, Maine Coastal Area.

j. Minerals.

(1) Quadrangle mapping of selected areas.

(2) Airborne magnetometer surveys.

No estimate of cost of the minerals features of the Coordinated Basin Plan has been made.

k. Insect control.

(1) Investigations to determine the best methods of control of black flies, punkies, and deer flies.

(2) Coordination in the planning of locations for recreation areas and wildlife areas so that the measures taken for control of insects at recreation areas can be effectively

instituted when necessary without adversely affecting wildlife, and so that the establishment of wildlife areas will not cause insect problems at recreation areas or centers of population.

(3) Assistance to urban areas, rural camps, and resorts in problem evaluation, and initiation of control measures. Estimated average annual control cost for all urban areas \$2,500. Estimated average annual control costs in rural camps and resorts \$400 per unit.

APPRAISAL OF THE COORDINATED BASIN PLAN

16. The appraisal of the Coordinated Basin Plan is influenced by the fact that the plan is offered as an inventory of possibilities rather than as a definite program for implementation in accordance with a specified time schedule. Monetary values have been assigned to benefits which can be identified and measured. Intangible benefits are described. Cost estimates are based on 1949 prices and annual charges include amortization, interest, maintenance and operation. The amortization period is taken as the anticipated useful life of structures. In general, the interest rate is taken at 2-1/2 percent for public works and 4 percent for private works. The annual costs of features of the plan which are of a private nature are based on private financing, while features that would normally be provided by municipal, State or Federal agencies are based on public financing.

17. Water supply. - The benefits from the water supply investigations included in the Coordinated Basin Plan are intangible but the findings would help users of ground water by indicating source areas and economical methods of obtaining an adequate supply for domestic or agricultural purposes. The study of supplemental irrigation would give warning when this use threatens to infringe upon other water uses. The annual cost of the supplemental irrigation investigation would be approximately \$500. The estimated cost of the investigation for the availability of ground water is \$10,000.

18. Pollution control. - The pollution control features of the Coordinated Basin Plan would improve the water quality of the now polluted reach of the main stream from Woodland to Passamaquoddy Bay. In addition to increasing aesthetic values and reducing the chances of waterborne diseases, pollution control measures would increase the utility of the waters for almost all purposes. The benefits of pollution control have not been assigned a monetary value. The first cost of the pollution control measures would be \$1,569,000 and the annual charges \$249,000.

19. Fish and wildlife. - The fish and wildlife features of the Coordinated Basin Plan would provide for correction of abuses and deficiencies existing in fish and wildlife resources of the basin. Improved hunting and fishing conditions would

benefit local residents and would attract to the area additional sportsmen whose expenditures would add to the income of residents catering to their requirements for food, lodging, guides and equipment. The benefits are intangible and the costs have not been estimated.

20. Recreation. - Both tangible and intangible benefits would result from further development of the resources along the lines of the recreational features of the Coordinated Basin Plan. Tangible benefits are represented by the monetary expenditures of visitors patronizing the recreation areas and facilities. The annual benefits attributable to the plan are estimated to be about 10 percent of the estimated increase in gross annual expenditures, or about \$205,000. Annual charges are estimated to be about \$96,000 giving a benefit-cost ratio of 2.1 to 1.0.

21. The improvement in physical and mental well-being of recreationists has always been recognized as a prime purpose in the development of outdoor recreational facilities. The recreation features of the Coordinated Basin Plan would provide such intangible benefits to an increasing number of persons.

22. Minerals. - The minerals features of the Coordinated Basin Plan would complete geologic mapping of selected quadrangles and indicate the location of mineral deposits of commercial value. The benefits are not capable of monetary evaluation but they would be of assistance to engineers, miners and prospectors and might

result in the inauguration of profitable new industries. No estimate of cost has been made.

23. Insect control. - The insect control features of the Coordinated Basin Plan would make it possible for camps, resorts and communities to control insect pests. While the benefits are not capable of monetary evaluation, they would make life more comfortable for residents and visitors, and indirectly benefit the recreation business by encouraging vacationists to stay longer and return. The cost has not been estimated.

RECOMMENDATION

24. The Committee recommends that the Coordinated Basin Plan, as heretofore described, serve as a guide for the development, conservation and use of the land, water and related resources of the St. Croix River Basin.